REPORTS

...RISBURG
PENN'A.

ON THE

GRAND WATER WAYS

OF

PENNSYLVANIA,

MADE BY ORDER OF CONGRESS, UNDER DIRECTION OF THE UNITED STATES CORPS OF ENGINEERS, IN THE YEARS 1878, 1879 AND 1880.

PRINTED FROM THE ORIGINALS ON FILE IN THE ENGINEER DEPARTMENT, BY ORDER OF THE SENATE AND HOUSE OF REPRESENTATIVES OF THE COMMONWEALTH OF PENNSYLVANIA, SESSION OF 1881.

WITH

A SKETCH SHOWING LOCATIONS AND PROFILES.

HARRISBURG:
LANE S. HART, STATE PRINTER.
1881.

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VIRTUE
LIBERTY AND
INDEPENDENCE

ADVERTISEMENT.

In the latter years of General Grant's administration the attention of the different States was drawn to the subject of water ways as a possible remedy against high charges for transportation on railroads. The subject received the attention of Congress. An able committee of the Senate, of which Hon. Wm. Windom was chairman, discussed it and reported upon it. The claims of Pennsylvania were laid before that committee and the lines alluded to, but the surveys were not ordered until after the committee had reported, giving preference as a beginning of the system to the great James river and Kanawha canal. It will be seen from the following reports that Pennsylvania's claim is at least as strong as Virginia's in reference to a line from the Ohio valley to tide water; and that the line even connecting the great lakes with the ocean and passing through Pennsylvania is little, if anything, behind the Erie canal as a similar thoroughfare.

Should canals ever again be called into requisition, and they are being resuscitated in many parts of Europe at the present time, Pennsylvania presents locations for great works of this kind which cannot be ignored in respect to practicability and facility of construction.

KISKIMINETAS AND CONEMAUGH RIVERS.

Letter from the Secretary of War, transmitting report of Major William E. Merrill, Corps of Engineers, of the results of an examination of the Kiskiminetas and Conemaugh rivers, Pennsylvania.

WAR DEPARTMENT,
WASHINGTON CITY, *March 1, 1879.*

The Secretary of War has the honor to transmit to the House of Representatives copy of letter from the Chief of Engineers of this date, and accompanying report of Major William E. Merrill, Corps of Engineers, of the results of an investigation made in compliance with section two of the river and harbor act of June 18, 1878, of the Kiskiminetas and Conemaugh rivers, Pennsylvania.

GEO. W. MCCRARY,
Secretary of War.

The SPEAKER *of the House of Representatives.*

OFFICE OF THE CHIEF OF ENGINEERS,
WASHINGTON, D. C., *March 1, 1879.*

SIR: I have the honor to submit herewith a copy of a report to this office, from Major William E. Merrill, Corps of Engineers, of the result of an examination made, under his direction, to comply with provisions of section 2 of the river and harbor act of June 18, 1878, of the Kiskiminetas and Conemaugh rivers, Pennsylvania, with a view to the improvement of their navigation.

As these streams formerly formed part of the old through freight-line of Pennsylvania, Major Merrill deemed it of interest to embrace in this report such facts as could readily be procured touching the possible restoration of this line of transit between the Ohio and tide-water.

Very respectfully, your obedient servant,

H. G. WRIGHT,
Acting Chief of Engineers.

Hon. GEO. W. MCCRARY,
Secretary of War.

EXAMINATIONS OF THE KISKIMINETAS AND CONEMAUGH RIVERS.

UNITED STATES ENGINEER OFFICE,
CINCINNATI, OHIO, *February 12, 1879.*

GENERAL: The examination of the Kiskiminetas and Conemaugh rivers, in Western Pennsylvania, ordered in the last river and harbor bill, was assigned to me by your letter of July 8, 1878.

Owing to the multiplicity of my other duties I was unable to take personal charge of this survey, and I therefore secured the services of Mr. James Worrall, civil engineer, a well-known canal engineer of Pennsylvania. This selection was appropriate from the fact that Mr. Worrall, some years before, had specially called the attention of the Senate Committee on Transportation to the importance of the water-line from Pittsburgh, via the Allegheny, Kiskiminetas, and Conemaugh, to the Juniata and the Susquehanna.

On learning that it was the desire of the advocates of this survey that it should not be limited to the two small streams that were named in the bill, but that they likewise wished, if time and circumstances would permit, to obtain some information as to the practicability of restoring the old Pennsylvania through freight-line that once ascended these streams, crossed the Allegheny by inclined planes, and connected with the Juniata at Hollidaysburg, I authorized Mr. Worrall to gather as much material bearing on this line as time and funds would permit. The results of this examination are given in his report and maps hereto appended.

When railroads were in their infancy, and canals and rivers were the chief modes of cheap transportation in regions deprived of navigable rivers, the great through line between the tide-water at Philadelphia and the head of the great Ohio valley at Pittsburgh was as follows:

	Miles.
Railroad from Philadelphia to Columbia,	90
Canal from Columbia to Hollidaysburg,	160
Inclined planes from Hollidaysburg to Johnstown,	50
Canal from Johnstown to Pittsburgh,	105
	405

The Kiskiminetas and its tributary, the Conemaugh, were a part of this through line, and as such had once been improved by canal and slack-water. It was therefore unquestionable that such an improvement could again be made if circumstances called for it. The question of feasibility, therefore, had already been demonstrated. The fall of the river from Johnstown to the mouth of the Kiskiminetas was also known with certainty, having been tested by actual construction.

There is no present necessity for any improvement of the Kiskiminetas and the Conemaugh. Should a radical improvement of the Allegheny be

carried into effect from Pittsburgh to Freeport, at the mouth of the Kiskiminetas, the question will then come up as to the advisability of extending navigable water up the Kiskiminetas and the Conemaugh to the city of Johnstown, a center of iron production which is second only to Pittsburgh.

These two streams will also require improvement should any effort be made to re-open the former central water-line of Pennsylvania.

In making an estimate of the cost of improving the Kiskiminetas and the Conemaugh, it was assumed that the navigation would be for boats of about 280 tons burden, and the same size of boat was used in discussing the water connection with the Juniata by tunneling the Allegheny.

The fall from Johnstown to Blairsville is 219 feet, and from Blairsville to the mouth of the Kiskiminetas 188 feet more, making a total fall from Johnstown to the Allegheny river of 407 feet. The estimates for a system of slackwater between these points (adding 10 per cent. for contingencies) amount to $3,667,000.

The work on the mountain east of Johnstown was undertaken with a view to reconnoiter the ground, and see if it were not feasible to restore and enlarge the Central Pennsylvania water-line, replacing the inclined planes by a through tunnel, and continuing the line from Columbia down the Susquehanna to the Chesapeake Bay. Neither time nor funds sufficed to do more than to decide the question of feasibility, and to make a rough estimate of cost. Should the restoration of this water-line be considered advisable, the mountain division should be re-examined with great care and in detail.

The conclusion from this summer's investigation is that the line in question is practicable, that the summit tunnel would be about $5\frac{1}{6}$ miles in length, and that the water-supply is ample. The dimensions of canal assumed in this report are the same as those assumed in my previous report on the Trans-Allegheny Canal from Pittsburgh to Cumberland, (Report of Chief of Engineers, 1876, part 2, page 58), being a canal prism 70 feet wide and 7 feet deep, with locks 20 feet wide and 120 feet long.

These lock dimensions are about 20 per cent. larger than those of the Erie canal, and considerably larger than those of the existing Pennsylvania canals. They would accommodate boats of two hundred and eighty tons burden. The elevation above sea-level of the proposed summit tunnel is the same as that of the proposed tunnel near White Sulphur Springs on the James River and Kanawha line, and two hundred and forty-four feet lower than the proposed tunnel on the Chesapeake and Ohio line

It has been assumed that independent canal will only be built where it is impracticable to establish slackwater. The latter has the great advantage of giving greater freedom of motion for boats, and of serving both banks of the river. It is also assumed that should this water-line ever be opened it will be chiefly navigated by self-propelling vessels.

The rough estimate on the whole line from Havre-de-Grace to Pittsburgh is as follows:

Havre-de-Grace to Frankstown,	$10,720,000
Frankstown to Johnstown,	15,607,000
Johnstown to Pittsburgh,	4,518,700
Approximate cost,	$30,845,700

If to this we add $5,400,000 for doubling the locks and then add ten per cent. for contingencies, we obtain $40,000,000 as the total approximate cost of the through water-line from Havre-de-Grace to Pittsburgh.

It must be borne in mind that no examinations were made except between Frankstown and Johnstown, the estimates on the remainder of the line being made on the basis of former surveys and examinations on file at Harrisburg.

Further details may be found in Mr. Worrall's report.

Respectfully submitted.

WM. E. MERRILL,
Major of Engineers.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

REPORT

Of a reconnaissance of the Kiskiminetas and Conemaugh rivers, Pennsylvania, made in the autumn of 1878, with a view to the said streams being made navigable. Proposing also a connection of the Ohio river at Pittsburgh, Pennsylvania, with the head of the Chesapeake bay at Havre-de-Grace, Maryland, by way of the valleys of the said streams and those of the Juniata and Susquehanna on the eastern slope of the Allegheny mountains. Made under the direction of Major William E. Merrill, U. S. corps of engineers, by Mr. James Worrall, assistant engineer.

HARRISBURG, PA., *January 28, 1879.*

SIR: In the disposition of the many important works confided to your charge you conferred upon me the honor of reporting upon the capacity for improved water communication of the Kiskiminetas and the Conemaugh, a system of streams so named, heading in the Allegheny mountains in Cambria and Somerset counties, Pennsylvania. In proposing to myself the mode of fulfilling this honorable trust, I had to consider the history of the water courses in question, in which history it is not boasting to say that I was already to some extent informed. For along the Kiskiminetas and the Conemaugh the main eastern and western transportation of Pennsylvania had moved for a great many years, and at the present moment those streams are bordered by the Pennsylvania railroad for some scores of miles. To be unacquainted, then, with the streams mentioned, was to be unacquainted with the carrying history of Pennsylvania.

From the foot of the Allegheny mountain at Johnstown, on the Conemaugh, so down to the Kiskiminetas, of which the Conemaugh is a tributary, and again down to the mouth of that stream at Freeport on the Allegheny, and thence by that river to Pittsburgh, formerly existed the western division of the main line of the Pennsylvania canal, forming a continuous water communication something over one hundred miles in length. This being the fact, there was not much surveying needed in order to ascertain whether the Kiskiminetas and Conemaugh were capable of being improved at least to the capacity of say a sixty or seventy ton boat, for they had been improved to that extent, and along their banks many millions of tons of our great country's productions had been transported through a period of more than a quarter of a century. These streams had, in fact, helped to form Pennsylvania's great canal system.

This system was carried east over the Allegheny mountain by means of a portage railroad some forty or fifty miles long, attaching at Holidays-

burg, the eastern foot of the Allegheny mountain, with another canal, which conducted the products along the valley of the Juniata to the Susquehanna and to tide-water. The whole line, commencing at the east, consisted of about ninety miles of railway from Philadelphia to Columbia, one hundred and sixty miles of canal from Columbia to the foot of the Allegheny mountain, say fifty miles of portage railway across the Allegheny mountain, and about one hundred and five miles of canal and slack-water from Johnstown to Pittsburgh, via the Conemaugh, the Kiskiminetas, and the Allegheny rivers. The series was called the main line of Pennsylvania's public works, and was about four hundred and five miles in length, perhaps a little longer.

This work was commenced in the very infancy of engineering in this country, and that a great work like this could have originated and been carried out to successful completion at such a time, does high credit to the brains and hands of the day in which the work was begun. The little appropriation for the examination of the Kiskiminetas brought up the whole history of this grand and successful undertaking, and the circumstances attending its birth were endeavored to be ascertained. In 1824-5, so long ago as that, a board of canal commissioners was created, and they were authorized to submit a plan for a carrying line through Pennsylvania. In this board there was no professional engineer except Mr. Charles Trezivulny (pronounced Treeoolny,) who was not known to have much practice, though he was intelligent and well read in the exact sciences. The board was authorized to employ an engineer, but the only experienced engineers then in the country were so busy that they could not give their time to our commissioners.*

*NOTE.—It may as well be stated here that these great water-ways had all been the subject of profound consideration with the leading men of the Republic from and even before the period of the Revolution down to this time. It is only necessary to refer to the biographies of these worthies to satisfy any person on the subject. Franklin actually left money in his will to carry out the great line from Philadelphia, west; Washington, in his younger days, had personally explored this whole region, and as surveying was a speciality with him, he could scarcely help but notice the country with a view to the facility of transportation through it. It was well known also that the General was something of a projector in matters of this kind. His name is found in connection with the old Potomac canal, the Dismal Swamp canal, and other great works of the day. Mr. Jefferson alludes to the subject carefully in his "Notes on Virginia," enumerating the passes, and showing that the physical geography of the country presents no serious obstacle against the construction of avenues over which can be transported the multitudinous wealth in product of the great West to the seaboard. And Mr. Monroe draws the attention of Congress to this very work in his message of February 14, 1825, from which it will be seen that a Board of U. S. Engineers considered the subject simultaneously with the Pennsylvania Board of Canal Commissioners of that day, and agreed with that board in recommending the practicability of the work. Had not the question of internal improvements by the General Government been decided adversely shortly afterwards in General Jackson's time, works of the kind would have been undertaken in all parts of the country. Mr. Monroe was in its favor, but General Jackson foresaw so many evils growing out of it that he "put down his foot," and the idea was set aside. General Jackson was probably right; the country was not prepared for a system of the kind at the time. There would have been extravagance; there would have been log-rolling; there would have been thrown

The board, however, set itself to work with a will, and proposed a plan, running nearly five hundred miles of levels during that season, in order to obtain data for the same. They proposed a plan which, notwithstanding their total inexperience, had it been carried out, would have created a work which in all probability would have been in operation to-day. They projected a continuous canal from tide to the Ohio, tunneling the Allegheny mountain, instead of crossing it by a portage railway. This was, as has been stated, in 1824-5. The tunnel would have been nineteen hundred feet above tide, and was to be four miles and one hundred and twenty-seven perches long, passing from the head of Blair's creek to Lillies' Mills. They gauged the water supply of the Allegheny mountain, and deemed they had a sufficiency. They certainly had a sufficiency, for at this moment there is enough water there to supply a canal of about four times the capacity then proposed. But their plan was rejected for a portage railway; their continuous canal, as easily navigated in the gorges of the Allegheny mountain as along the reaches of the quiet Juniata, was supplanted by a portage from Hollidaysburg to Johnstown, a transshipment at each place. Ten inclined planes, with a machine shop attached to each, the whole finding itself eventually under the charge of a set of politicians. Costly as the tunnel would have been, expensive as the water supply must have proved, the cost would not have compared with the vast amount of direct and indirect expense which resulted from the interrupted system of transportation, the two transshipments and the ten inclined planes. Had the tunnel plan been adopted there would have been a great many lock-keepers, true, but their pay would have been, say, eight to ten dollars per month and their house shelter, that is all. The canal would have been like a navigable river from whose shores every person might push off his little bark to go where he pleased along its line. And as for the difference in cost that would have been against the tunnel in the beginning, but as things turned out, compare the annual expense of the portage with its nucleus of machine shops, its transshipments at both ends, (worth fifty miles of transportation each, as estimated by engineers of experience,) and the element of politics which finally got a permanent foothold on the portage, and the tunnel system would have been found to be infinitely the cheaper of the two. This could be shown in figures, but where the use? The dollars are gone never to return, and an enumeration of them is left to the judgment of those who may consider this subject. It is quite as useless to count the eggs broken or addled as it is the chickens, previous to completed incubation. The tunnel would have cut two or three veins of coal, which alone would have very much more than paid for it up to this time, and what is better, would have insured its continuous existence.

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away, and worse than thrown away, vast amounts of money. But have not similar evils taken place as it is? Witness the millions of private funds that are irrevocably lost by the private construction of public works. Now, however, that we have gained all this experience and have learned, if we will remember it, the lesson what to guard against, the question may well come up again and call for the most careful consideration.

But the portage system was adopted, it was skilfully planned and ably constructed, it served a good turn. But the continuous Pennsylvania railway came along side of it, and soon proved that transshipment was an inconvenience which was not to be borne. So in the natural course of events the portage disappeared. Even a new portage without inclined planes was tried, but that had to give way, the two transshipments proved to be too great an interruption.

Had the tunnel been adopted as recommended by the first board of canal commissioners, by the time the railway began its competition, the works would have been perfected, reservoirs created, the water supply made sure and the canal would have remained as many important canals remain, by the side of railways, relieving them of the heavy onerous part of their duty, as the Erie canal remains, as the Delaware and Raritan, the Schuylkill, and a great part of the Pennsylvania canals would have remained until the question should have been settled by absolute experience, which is the cheaper mode of transportation. Many canals in Europe, which were driven into desuetude by railways, are reasserting themselves to-day, and say what we will, the question is not yet settled.

So long as railways can be built and their first subscribed capital be allowed to sink, claiming no remuneration, freight can be carried on railways at an apparently lower price than on canals. But can it be that it is cheaper to carry freight over the Allegheny mountain in cars, requiring from two to three locomotives to move them, when six or eight mules at the furthest will move the same load over the same mountain in boats? True, the two or three locomotives can come back two or three times for their forty loaded cars whilst the mules are moving the boats, dragging their slow length along,* but admit it, which is the cheaper method? Inspection would give the answer in favor of the boats, even calculation would do so. Yet the locomotives seem to be preferred.

But, now, let us see. Suppose a canal, let it be well constructed, placed with good judgment, beyond the reach of floods, supplied adequately with water from reservoirs which built with the skill and experience of the present day never wear out, and unless badly constructed, never break, except by an earthquake or a cataclysm, that may not occur for ages, and excepting, always, of course, the mischief of bad men, which, let us hope, is equally far off. Compare a boat capable of bearing two hundred tons, three or four mules, two men, and one boy; your boat at a cost of two thousand to twenty-five hundred dollars; your mules at a cost of, say, six hundred dollars. Now, take your locomotive, at a cost of $10,000; your ten cars, at a cost of five to six thousand dollars; your steel rails, at a cost per ton of fifty to sixty dollars; and these hammering at each other, the knocks going and coming with a deafening noise that can be heard for a score of miles of a still night. Compare your locomotive-engine driver, your staff of brakesmen and stokers, and your fuel. Compare the noise that the two

* This comparison has reference to boats of the Erie canal size.

methods make, and noise is produced by friction; friction, in the nature of things, being the cause of all labor and cost in this world. The noise of the boat is the klinking of the mules' harness and their tramp upon the towing path. To be sure, the driving boy, clattering along, building his air-castles, or, mayhaps, studying for the Supreme Bench or to be President of the United States, each of which aspirations such boys have realized. The driving boy can make a noise with his post-horn, or like Cymon, in the story, whistle as he goes, for want of thought; but those noises don't cost much. The capital for vehicles in the one case is, say for locomotive and cars, at least $15,000; in the other, the boat, say $2,500, the mules, say $600, or $3,100 in all. I speak now of the loads that cross the Allegheny mountains, putting the cost of the pathway as the same in both cases, except the steel rails, which assist the locomotion and wear out in yielding that assistance. But does a canal wear out so fast as a railway, supposing both to be built in the best manner? Let a canal be built in the best manner for a two or three hundred ton boat, and give it its full business; a quarter of a cent per ton per mile will keep it up. This is an inevitable expense, and in all probability can never be reduced. Will a quarter of a cent per ton per mile keep up a railway, multiply its business as you may? Questionable. We must look forward to the time when carriage shall be reduced to a minimum. It is too important an element in man's affairs to be left to the chops and changes of speculative values. It may some day or other be placed in the hands of the Government to be managed, as carrying letters and coining money are now. We carry our letters at a minimum cost, because the duty has been conceded to the Government, and so deeply does the subject effect the interest of all that the duty is performed honestly.

Why may not all carriage be so placed? Bacon, the "wisest, brightest, ——." I leave out the poet's third superlative. *De mortuis nil nisi bonum* is a maxim always to be observed in the case of the poor Lord Chancellor, though one is sadly tempted to break it, for to the lowest depths of human meanness did he stoop. Bacon, nevertheless the most far-seeing individual of Anglo-Saxon mankind, warned the king's minister and favorite, whose duty it was to take care of the public interests—warned that young nobleman nearly three centuries ago against placing "carriage" in private hands. Improve your public ways, make your rivers navigable, he says, but let not the profit of transportation fall into private hands.* Is not the profound wisdom of this advice manifest to us at this very moment? See the confusion into which transportation has fallen, exclusively because it is in the hands of monopolists—because it has been "turned to private profit." True, we fell into errors whilst the State did the carrying;

* I may as well quote the exact words from Bacon's letter to Sir George Villiers, afterwards Duke of Buckingham, on his becoming prime minister to James I: "A very great help to trade are navigable rivers; they are so many indraughts to attain wealth. Wherefore, by art and industry let them be (so) made, but let them not be turned to private profit."—*Bacon's Works. Cary & Hart's edition, 3 vols., 8vo.*

but these would eventually have been corrected, for public opinion can "get at" the State more easily than it can help to regulate private corporations.

Until the money expended upon railways and lost shall be forgotten; until you can ascertain the absolute average worth of a railway per mile, and the absolute net dead cost of moving a ton of goods upon it, and then upon these two costs predicate a price for transportation which will pay a fair interest on first cost and provide a sinking fund which will rebuild the railway when it shall have been worn out, you will never have ascertained what to ask for transportation.

But when that time comes, then you can compare the two methods, by canal or by railway.

Canal navigation will always have this advantage, that every man can make use of it—every human creature, from the little boy and his toy sailboat to the great forwarding merchant and his fleet of vessels, or the great iron company, disbursing millions a year for its freight alone.

Railway companies may always, rightly or wrongly, "discriminate," having hundreds of reasons, fair or other, for doing so. The canal can make no discrimination; its owners have but to keep it up, and a woodchopper with his scow, a quarryman with his flat, a miner with his barge, an oil producer with his floating tanks, all can have their wharves and their basins, and can send away their vessels laden or unladen, whenever it suits their convenience, paying uniform tolls at the proper collector's offices.

But with a railway it is different; its transportation must be managed by its owners and at their set time, or there would be inextricable confusion, and as long as this is so there will be discrimination, and any discrimination will find those who will consider it unfair, be it so or not.

The question will come down then to the characteristic of celerity. Where prompt delivery is an unavoidable necessity the railway will be preferred; where that is of no special importance the canal will be chosen. It is questionable whether both systems will not be eventually required for a densely populated country of enterprising people.

Railways are undoubtedly a necessity for travel; they are, in fact, indispensable. But canals, if you can carry your ores, your salt, your metals, your oil, your fire clay, your lumber, even your heavy groceries and your cereals one half cheaper on a canal, and if there be water enough along the country side to supply your canal, shall it not be built even alongside of your railway? Will the Erie canal of New York ever be suffered to go down? To undertake to suppress it even at this time might easily cause a revolution, and if that be so, if you can build a canal through Pennsylvania equal or superior to the Erie canal, and uniting a region as valuable and as extensive as the lake region with the ocean, shall such canal not be built? If the advice of Pennsylvania's first canal commissioners, "Jimmy" Clark, as he was familiarly and in many cases lovingly called by the peo-

ple, and Jacob Holgate, had been taken, Pennsylvania would have had such a canal now.*

For although the canal they proposed was not as large as the Erie canal of to-day, it was the size of the Erie canal of that day, and had it been built would it not have been enlarged when the Erie was enlarged, and if proved to be equal to the Erie canal, could it have been taken away from us as the other was? No; we should have had it to-day, as the New York people have theirs. But the plan was rejected which was recommended by "Jimmy" Clarke and Jacob Holgate in as able a report as was ever laid before the Legislature of Pennsylvania on such a subject. The plan was rejected as much (as your assistant was informed by a distinguished Governor of the State, himself a State Senator at the time) because of the quaint definition the commissioners gave of a tunnel as for any other cause. The commissioners said in their report that a tunnel was a "horizontal well."† The Legislature guffawed and rejected the plan without giving it serious consideration, the idea of a horizontal well costing a couple of millions was too much for them. Wit and humor was expended upon the occasion; one gentleman suggested the cutting up of the big well into a series of small ones and distributing them amongst the people. Vulgarity talked about "Jimmy" Clarke's big hole in the ground," etc., etc. Mr. William Strickland, a distinguished architect, but unknown as an engineer, was put in charge of the works. The tunnel line was ignored and a portage adopted. Mr. Strickland was called away to build the crowning work of his life, the capitol at Nashville, and the works were given in charge to several able engineers, who were not consulted about the general plan; they were simply set to building the works, the portage as a matter of course, and finally the tunnel was as good as forgotten. The portage was

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*Jacob Holgate represented the city of Philadelphia in the House of Representatives in 1815, and that year was Speaker of the House. His name appears frequently thereafter until he became canal commissioner, as has been seen, in 1824–5. Devoted to the service of his fellowmen to the last, he died of yellow fever in 1832, having exposed himself to the pestilence in endeavoring to save the lives of others. A grandson of Colonel Holgate, Hon. James Holgate, represents the city in the Legislature now in session—1879. The Holgates were English Quakers and came over with Penn.

James Clarke, although born on the banks of the Kiskiminetas, was typically Scotch-Irish. His parents came from that little area of the Emerald Isle, not more than forty miles square, which gave this country in the second generation only no less than five of her Presidents, gave the South its Calhoun a heroic character whose value to mankind was lost from his having been born in a community cursed by the system of slave labor; gave New York its Stewart, Philadelphia the Browns, St. Louis its Campbell, Pennsylvania its Breckenridges, and many others. Clarke was pre-eminent for his sound, sober judgment, and perfect integrity. He served the State to a late period of his life, always in connection with her public works, and he died with perfectly clean hands A son of Mr. Clarke, Hon. James C. Clarke, represents (1879) the Westmoreland district in the Senate of Pennsylvania.

†The exact words are "A tunnel is a passage like a large well dug horizontally through a hill or mountain when there is not water enough to lock over it, or when the lockage would be too expensive."—*Canal Commissioners Report, Pennsylvania, Senate Journal, 1824–5.*

adopted, which, first and last, cost the State *n* millions of dollars over and above what the tunnel line would have cost. Which *n* may be taken to represent any number of millions between ten and twenty—nearer the latter than the former—and they deprived the State of a continuous canal from tide to the Ohio, which, in all human probability, never would have gone down as the broken work was in a great measure allowed to do.

This first distinguished canal board consisted of James Clarke, (from the west,) Jacob Holgate, (from the east,) and Charles Trcziynlny, (from the center,) of the State. Justice must be done as regards the latter gentlemen, scientist though he was, and most probably practiced as a civil engineer in his own country or elsewhere on the continent of Europe, and from the preponderance of consonants in his name, his native country may be taken to be either Hungary or Poland. He not only did not sign the first report, but wrote a minority report against it. History will give him the credit due to his judgment. The writer of this report would have been proved to be a consignatory with Messrs. Clarke and Holgate, men whose superiors for the position conferred upon them, probably did not exist in Pennsylvania at the time, men who, though unlearned, were of a kind not easily surpassed at any time, either in respect to integrity or good judgment. And although their plans were rejected, nay scoffed at, they had not long to wait for vindication of the first class. The distinguished General Bernard, one of the first Napoleon's most distinguished engineers engaged, if I mistake not, on the Simplon pass, a work that confers higher distinction on the greatness of that extraordinary personage than any of his Imperial honors have done. General Bernard, at or near the spot or space on which our plain Pennsylvanians proposed to locate their water way across the Allegheny, pronounced the project entirely practicable. I do not know that there is not amongst the archives of the Government written evidence of this fact.* I have it from the people who heard the opinion pronounced in 1827, when the General was consulted in regard to the proposed internal improvements of the United States.

Were I to content myself with a report on the capacity of the Kiskiminetas and the Conemaugh, I might very easily do it here by saying that these streams can have their artificial navigation restored, enlarged and connected with the forks of the Ohio at Pittsburgh, upon the same scale as that proposed for the Chesapeake and Ohio canal, embracing a distance of about one hundred and five miles. Beginning at Johnstown, Cambria county, Pennsylvania, for the sum of $4,818,700, being the cost, with the addition of a reservoir on Stony creek, estimated at $300,000, of that portion of the Havre-de-Grace and Pittsburgh water-way, as reported further on. But the subject I have suffered to expand under my hands, and I trust that my suggestions in reference to it will be received with patience, at least, if not with consideration.

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* There is such evidence ascertained, but the fact will be believed without producing it.

General Grant, in his message of 1873 or 74, submitted to Congress the idea of a series of grand water-ways for the transportation of the interior productions of the country to the seaboard. Congress took the subject up and placed it in the hands of a committee of the United States Senate, distinguished for its ability, whose chairman was the Hon. William Windom, of Minnesota. That gentleman reported on all the water-ways joining the valley of the Mississippi with the ocean, from the Mississippi itself to the Erie. He treated the subject with his accustomed ability and research. And in summing up he recommended, as the first one of these great lines of transportation to be assisted by the Government, the James river and Kanawha canal, uniting Point Pleasant, on the Ohio, with Richmond, in Virginia.

The James river and Kanawha canal is 475 miles long. Its summit level is 1700 feet above tide, and it requires a tunnel through the mountains 7.8 miles long. You, yourself, have reported upon the Chesapeake and Ohio canal, connecting Pittsburgh with Washington city. Its summit level is 1944 feet above tide. It requires a tunnel 3.75 miles long and the water-way is 341 miles in length. Benjamin Aycrigg, Esq., a civil engineer of great industry and research, recommended in 1836–7, (see Canal Commissioner's Report in Pennsylvania State Senate Journal of that period,) a canal from Pittsburgh east, which, if extended, may terminate at the same point as this water-way which I have now the honor to report upon. It passes along the Allegheny river to the mouth of the Red Bank, and thence by Bennett's Branch of the Sinnemahoning and the West Branch of the Susquehanna, descends to the mouth of the Juniata. Whence to the Chesapeake bay it is upon the same ground that the present work proposes to occupy. Indeed, from Pittsburgh to the mouth of the Kiskiminetas, the ground covered by both systems is the same. Its summit level is about 300 feet lower. I have not been able to find the exact figures, but these I know to be very near the truth, from leveling done under my charge. I don't know that a navigable tunnel is necessary, though tunnels uniting reservoirs are altogether probable.

Colonel Aycrigg's work would be sixty-five to seventy miles longer than ours, and this, presuming water to be in full supply, about offsets the difference in lockage, a question of time exclusively, barring the keeping of the locks and some waste of water. There is enough water to be had in either case, but if, against all probability, there should not be enough, there is as much reason to fear that trouble in one case as in the other.

I shall make no invidious comparisons, but simply state facts. So, in recapitulation, let us announce the facts simply.*

1st. The James River and Kanawha.

Point Pleasant, West Virginia, to Richmond, Virginia, 475 miles artificial water-way + 80 miles natural water-way to Hampton Roads = 555 miles

*These remarks were made prior to the examination of the Red Bank line, *q. v.*

to the open ocean. Summit level, 1700 feet above tide. Length of navigable tunnel, 7.8 miles.

2d. The Chesapeake and Ohio canal.

Pittsburgh, Pennsylvania, to Washington, D. C., 341 miles artificial water-way + 140 miles natural water-way to Hampton Roads = 480 miles to open ocean. Summit level, 1944 feet above tide. Length of navigable tunnel, 3.75 miles.

3d. The Kiskiminetas water-way.

Pittsburgh to Havre-de-Grace, 355 miles in round numbers + 200 miles to Hampton Roads = 555 miles to the open ocean. Summit level, 1700 feet above tide. Length of navigable tunnel, 5.17 miles.

[NOTE.—Should a ship canal for the accommodation of Baltimore be made from the Chesapeake to the Delaware bay, the seaport on the Delaware bay, at the mouth of such canal, will not be more than 40 miles from Havre-de-Grace. The figures 555 then in the Kiskiminetas case will become 395.]

4th. The Red Bank line is entitled to the same memorandum as the Kiskiminetas, changing 355 to 420, and making the other changes which that change would effect. The tunneling would be inconsiderable, and the summit level would not exceed 1500 feet in elevation above tide.

5th. A line is possible via Black Lick, a branch of Kiskiminetas, and the West Branch of the Susquehanna. The memorandum as to Red Bank would apply equally to this, though this may be from ten to twenty miles the longer of the two. The summit level would scarcely be higher nor would much navigable tunnel be exhibited on this alternate.

With our present information I would prefer the Kiskiminetas, Conemaugh and Juniata line, and shall use it in comparison with the others as if it were to be the chosen one. *Prima facie* it is always at least sixty-five miles shorter than the Red Bank or the Black Lick line.

Now, suppose the Ohio to be made navigable to a uniform depth and a barge to be in the river above Cincinnati, its cargo destined for any point north of Delaware bay, including Philadelphia, the distance it would have to travel in order to reach a point on or opposite to Delaware bay on the ocean, equally distant from (the point of) its ultimate destination, be the chosen route what it may, these would be about the figures:

Route via James river and Kanawha.

	Miles.
Point Pleasant to Richmond,	475
Richmond to the sea,	80
By sea to *Waremouth* (to create a name for the port at the mouth of the proposed Chesapeake and Delaware ship canal on Delaware bay),	150
Total,	705

Route via Chesapeake and Ohio.

	Miles.
Point Pleasant to Pittsburgh,	263
Pittsburgh to Washington, D. C.,	341
Washington to the sea,	140
By sea to *Waremouth*,	150
Total,	894

Route via Kiskiminetas Water-way.

	Miles.
Point Pleasant to Pittsburgh,	263
Pittsburgh to Havre-de-Grace,	355
Havre-de-Grace to *Waremouth*,	40
Total,	658

The lockage, (actual passage through locks,) suppose the Ohio to be made navigable without them, via the James river and Kanawha would exceed that on the Kiskiminetas water-way by the fall between Pittsburgh and Point Pleasant equal eighty-seven feet, though the final elevation to be overcome would be exactly the same. But the extra lockage, via the Chesapeake and Ohio route, would be $244 \times 2 = 488$ feet. Were the cargo of our barge destined for Norfolk or points south, however, the distances would be—

Route via James River and Kanawha.

	Miles.
Point Pleasant to Richmond,	475
Richmond to the sea,	80
Total,	555

Route via Chesapeake and Ohio.

	Miles.
Point Pleasant to Pittsburgh,	263
Pittsburgh to Washington, D. C.,	341
Washington to the sea,	140
Total,	744

Route via the Kiskiminetas.

	Miles.
Point Pleasant to Pittsburgh,	263
Pittsburgh to Havre-de-Grace,	355
Havre-de-Grace to Hampton Roads,	180
Total,	798

So the south bound goods would better take the James river and Kanawha. But what about the north bound goods, (not a minority of the

trade, by any means?) I leave the calculation to those who may read this report. The figures are intelligible.

The Cost of the Works.

The James river and Kanawha is set to cost in round numbers, $50,000,000.

The Chesapeake and Ohio may be put, revised and enlarged throughout, at $30,000,000, (single locks,) or about $39,000,000 with double locks; this is a mere surmise, derived, however, from some knowledge of the country all along its line.

The Kiskiminetas, Conemaugh and Juniata at $40,000,000, our present estimate.

If a selection were to be made amongst the regions comprising the Cis Mississippi States of the most valuable piece of country for the size of it, (for its number of square miles in area that is,) I think it would be fair to choose the western slope and base of the Allegheny mountains, commencing at where the Allegheny river heads, and following that river and the Ohio down to, say, the Kentucky line, take in the area so inclosed.

Here we have coal, iron, petroleum, natural gas in unlimited quantity, fire-clay, salt, and even silica for glass, besides the sylvan and agricultural products. Pittsburgh is the result of the richness of that country—here that city finds its *raison d'etre.*

It would have been a respectable town in any case, supposing the country to have been merely agricultural; but how could it have been the hive of industry it is had it not been for the mineral wealth I speak of enclosed in the region which surrounds it. And again, Johnstown, at the foot of a rugged mountain; a smith's shop with ten thousand smiths and helpers, rolling out rails, weighing each five hundred pounds and over, faster than a country girl can deliver buckwheat cakes from her griddle. An incandescent loaf of iron is taken from an oven, and in less than two minutes can be laid down upon a piece of grading for cars to run on, were it only cool enough in that short space. This smith's shop paying close upon a million and a half of dollars *for freight alone* every year. Here's richness for you; and the whole region is the same. Johnstown is only a center because there is handy transportation both east and west, and there will soon be northern and southern communication equally facile.

As if nature anticipated the carrying necessities of such a country, we find streams heading in the mountains and trending toward the Allegheny river and the Ohio, all the way along, and all these streams can be made avenues for the transportation of all that wealth. Thus we have the Clarion, the Red Bank, the Mahoning, the Kiskiminetas, the Monongahela, the Youghiogheny, and their branches, the Guiandotte, Sandys, Little and Big, the Kanawhas, etc., all of them placed about where they were likely to be wanted, and all of them asking to be improved. Some of these have been improved already; some by railway, some by slack-water. Thus the Red Bank, the Kiskiminetas, the Monongahela, and the Virginia streams; but all must be eventually improved as water-ways, for such is part of their original des-

tiny. Some of them have complementary streams heading near to their heads, but on the east side of the summit of the mountain. Thus the Red Bank, the Mahoning, the Black Lick, etc., can be connected with the Sinnemahoning and the West Branch of the Susquehanna, and the Kiskiminetas and Conemaugh can be joined to the head waters of the Juniata.

The heads of the Monongahela can be connected with the Potomac, whilst the Kanawha may seek connection with the James river waters. It cannot be that this cheap system of water-carriage will be rejected by man. So all of these streams will eventually be improved; some carried across the mountain barriers, so as to deliver products at the seaboard; others only *to* the mountains, to facilitate the carriage of the mineral products to the Mississippi valley, which embraces the area drained by the Ohio.

The Kiskiminetas and Conemaugh route possesses high claims to be made a through work for reasons which may have been perceived already in the general tenor of this report; but it seeks no more than its due.

Let the improvement of the streams draining the western slope of the Allegheny mountain be carried on as it has been begun. The Kanawhas and their sister streams have already received attention The Youghiogheny asks for similar improvement, and so does the Kiskiminetas, when the improvements proposed for the Allegheny river shall have backed water into the estuary.

Let the Allegheny be permanently improved to the mouth of the Kiskiminetas, then advance gradually up the latter, adopting a style of work which can be made uniform all the way to tide water. So let the Youghiogheny partake of the same benefits, but let each region share and share alike; each region, that is to say, which is strictly and practically deserving of the improvements, each region or section that manifestly ought to be improved, in order to accommodate the teeming wealth of the magnificent piece of country under consideration. The subject being thus introduced, let us proceed to consider how we developed the project which was placed in our hands to report upon.

We have seen how Messrs. Clarke and Holgate proposed a through work; how their colleague, Mr. Trezivulny (commonly pronounced "Treeoolny") reported adversely; how the Legislature ridiculed and rejected the tunnel plan, and how General Bernard approved it when consulted on the subject a short time afterwards; how Mr. Strickland, the architect, was appointed engineer and eventually retired with honor to build the Tennessee capitol. Mr. Strickland's views were in favor of railways; he had just returned from Europe where they were just coming into vogue, and whether he planned the portage or not, his successors built it. They had nothing to do but carry out the plans adopted, and it must be admitted that they did it well. Sylvester Welch, Solomon Roberts, Milnor Roberts, Edward Miller, and others, were all engaged on the Portage, though Major Long, Mr. Moncure Robinson, Judge Roberts of New York, Mr. Olmstead, Mr. Morell, and others, were more or less consulted during its period of gestation and completion.

Mr. Alonzo Livermore's name also appears prominent amongst these early and able engineers; whilst Major Wilson, Mr. Edgar Thomson, Mr. Harris, Mr. Foster, Mr. Canvass White, Mr. Faries, Mr. Rawle, Mr. Guilford, Mr. Schlatter, Mr. Roebling, Mr. Wierman, Mr. Kneass, Mr. Hagé, and other prominent engineers assisted with the great work in other parts of the State.

The history of the great works of Pennsylvania could not be completed without prominent mention of these names, and others which can be found in the archives. The through canal was rejected, and the broken line adopted informally, or as the French say *sans dire*, apparently as a matter of course. People could not appreciate the "horizontal well" and "Jimmy Clark's big hole," as it was called.

A half century has passed by. The undersigned is called upon for an opinion, and he freely and unreservedly agrees with Messrs. Clarke and Holgate, confirmed by the judgment of General Bernard. Unless canals are set aside permanently by railways, and that fact is not yet settled, a canal here is eminently practicable, and he is not sure but this is the best line for a water-way that can be formed in Pennsylvania, from the Ohio to the sea. I have alluded to the others already and made certain comparisons that can be easily understood.

We had but a small amount of money at our disposal to help to make this examination. We knew, however, that canals had existed from Pittsburgh to Johnstown, and from Hollidaysburg to Havre-de-Grace. We hoped to be able, by ransacking the archives of Pennsylvania, to obtain as much knowledge of the canal-practicability of the canalled spaces mentioned as we could by a survey in the field, and we believe we have attained the knowledge after a good deal of searching.

Crossing the Mountain.

The crossing of the mountain was left for us to ascertain in the field and here we did our field-work. We knew that the first board of Pennsylvania Canal Commissioners had pronounced it practicable. It was left for us to verify the *dictum*. To do that we took a section of the Allegheny mountain summit, bounded north by the crossing of the Pennsylvania railroad, and south by that of the old Johnstown turnpike, and between these two crossings we ran a contour or girt line, at an elevation of 1,700 feet above the level of the sea. We knew that the old tunnel was some 200 feet higher in elevation, and that it was four miles and 2,095 feet in length. We would rather, in these late days, have a few extra rods of tunnel to bore than some 400 feet of lockage extra, up and down, so we adopted 1700 feet, that being, as we knew, less than the highest elevation of the Chesapeake and Ohio canal, and exactly the proposed elevation of the James river and Kanawha.

Our girt line gave us 105 square miles of water shed, at about 200 feet less elevation (or 400 feet less lockage) than the Clarke tunnel, for which we incurred in exchange about three fourths of a mile more tunnelling—a good exchange.

The size of our tunnel we took from your report on the Chesapeake and Ohio canal, a work crossing the mountain some forty miles south of us, accepting your reasoning in its favor as correct, except that we added to the tunnel height, or rather depth, two feet, which does two things for us, viz: gives us a reservoir two feet deep, forty-two feet wide, and five and seventeen hundredths miles long, and affords a space in the early use of the tunnel to hold fragments of rock dropping from its roof, which might otherwise impede navigation, giving us time, as it were, to clear them out of the way.

To be sure, this costs more than other reservoirs, but its conveniences are very manifest, and it will be found to be fully worth its cost. The sizes of our canal prism and lock chamber are copied from the Chesapeake and Ohio canal also, being some twenty per cent. larger in the lock—not in the prism—than the Erie canal, and affording navigation for boats of, say, two hundred and eighty tons burden, the lock chamber being one hundred and twenty by twenty feet, and the canal prism being seventy feet wide on the bottom and seven feet deep, the slopes being 2:1.

Of our approaches to the tunnel, that on the west is convenient and does not interfere with any competing interest. On the east the approach is easy, and at the same time grand and magnificent. The line leaves the tunnel going east in a cultivated field of Costello's farm on the mountain side, continuing down the valley of Poplar Run, which is for the most part cultivated. From the western end the line passing under the grade of the Pennsylvania railroad, near the mouth of Ben's creek, soon sinks to the bed of the Conemaugh, which it leaves only twice to reach Johnstown, in order not in any case to inconvenience the road or the Cambria Iron Company. The first withdrawal occurs in passing the mouth of the south fork of the Conemaugh where the space, though somewhat contracted, is sufficient. The line returns to the stream bed very soon and follows it to Conemaugh, where it is proposed to leave the stream again and reënter it below the confluence of Stony creek at Johnstown.

On the east, the line progressing east from the tunnel on approaching the village of Marion, popularly named Puzzletown, in the valley of Poplar Run, may turn to the left, and, tracing the depression opposite Newry, seek the old basin at Hollidaysburg, whence Frankstown will be reached by the old canal line, or it may continue along Poplar Run valley, reaching the main Juniata above the old reservoir, and so along to Frankstown, the east end of our summit division.

The above describes the summit division extending from Frankstown on the Juniata, to Johnstown on the Conemaugh, evidently the heart of this grand enterprise.

Water.

We will now say a few words about water. The rain fall of the Allegheny summit is 38 inches on the average. This would give on the area

above our tunnel, every foot of which, continuing on the surface of the ground, can be led to the tunnel 9,270,000,000 of cubic feet of water.

Cases are of record in which, where there was storage room, one half of the rain fall, and more, has been actually utilized. Supposing we had storage room, then we could use out of the above quantity 4,635,000,000 of cubic feet of water. But we have not that storage room, while we have storage room for 2,500,000,000 of cubic feet, although for the present we have only provided storage room for 1,257,000,000; but by an additional expenditure of $2,500,000 we could store the 2,500,000,000, an amount ample for the utmost possibilities.

The maximum possibilities of the canal may be set down at 288 lockages (ten feet lift) per day of 24 hours, including the business of both ends of the tunnel, and the season may be calculated as 244 days long, say from the 1st of April to the 30th of November, both days inclusive. This would require 1,686,000,000 of cubic feet, which, out of our 2,500,000,000, would leave 814,000,000, not quite fifty per cent., for contingencies and probable losses.

It may be mentioned here that the losses of the canal, if properly built, may be reduced to a very small minimum. For, 1st, The tunnel will lose no water, judging from the tunnels already bored through the mountain. 2d, The reaches of the canal, formed of the detritus soil of the Allegheny mountains, ought not to lose any water, and if they did it would be from bad engineering, which, it is to be presumed, need not be anticipated. 3d, The losses will be at the gate and admission valves, which, if properly constructed and attentively worked, can be made very nearly water tight. But, besides, an extra stop-gate can be put in at the upper end of each head lock, almost entirely water tight, relieving the valves of pressure during slack times and throwing pressure upon the valves only for the nonce. The 814,000,000 reserve, then, is a generous calculation.

But we calculate now on but 150 lockages in the 24 hours, which would be a very satisfactory business, and this number requires 878,500,000 which, deducted from our stored 1,257,000,000, leaves for a reserve and for loss 378,500,000. Again, a proportion between forty and fifty per cent., which will cover all contingencies, will cover indeed the contingency of a rain fall diminished considerably below the recorded average, a contingency which, of course, must be met. The water question, then, is at rest. The exigent parts of our water-way exist only between Johnstown and Frankstown. After that the canal may be said to be at the bottom of the country, where, as a matter of course, all the water flows. There may be, indeed, some independent canal on the main Susquehanna, but there there can be no question of water.*

In the flights of locks and their reaches either west of Frankstown or east of Johnstown, should a want be experienced, subsidiary reservoirs, lower

* We calculate, of course, that the reservoirs and the canal will be always full at the opening of navigation, as the *whole rainfall* of the winter can be led to our summit level, save soakage and evaporation.

than our main gatherers are practicable and sufficient, but, as I do not think they will be needed, I do not estimate for them.

Plan of Reservoirs.

The general plan of our reservoirs is as follows: A bank is thrown across the mouth of a gorge or ravine. It will, in general, be not more than 50 feet high, plus the guard height, say 6 feet, but for the sake of a large gathering it may be raised even to 100 feet. It will be 20 feet wide on the top, and slope on the water side 3:1; on the outlet side 2:1. It will be made impervious by puddling, and will be saved by proper paving or rip-rap from being washed. The outlets will be carried through drifts in the hill itself; the integrity of the holding bank must never be disturbed. We calculate our outlets to cost $12,500 on the average. We also calculate on a flood-weir or by-wash, which is to carry off the waters of sudden showers, if they should reach toward the top of our reservoir. These will be, say, 200 feet wide, and will be at the exact level of the reservoir when full. The retaining bank will be at least 6 feet higher, so that a stream, approaching 6 feet deep and 200 feet wide will be relieving the reservoir of the extra flood as that flood rises to the level of the holding bank. Now, unless the Allegheny mountain itself is unretentive our losses will be small. But, of course, there will be probing and all other preeautionary measures before a reservoir bank shall be located. These are all to be connected with iron pipes, and the whole series will discharge their waters finally into the tunnel at either end, as the case may be.

Large spurs of the mountain in front of our reservoirs we intend to drain toward us by means of catchment races. But we shall not go to that expense unless something worth while in the way of supply will be the result.

Inclined Planes.

I do not go into the subject of inclined planes, for we can have a "wet" canal. If, however, inclined planes should be adopted on great canals, they can be very easily applied on our eastern slope, not so easily, for several reasons, on the western slope. But we need not discuss the subject at present. It is for us to present the project of a great water-way upon the route proposed as practicable, which we do without hesitation. Inclined planes or not, let those who may be called upon to build the work settle the point. The whole work is eminently practicable; the water question is at rest.

The Erie canal is, and will remain a permanent outlet for lake products to the sea. Now, ought not the Ohio valley to have such an outlet? It ought, and this is as good an avenue for the Ohio as the Erie is for the Lake country.

From Buffalo to New York, via the Erie canal and the Hudson river, the distance is over 500 miles. By our line to the port on the Delaware (*Waremouth*) which will eventually be opened for Baltimore, the distance scarcely reaches 400 miles. Our canal is twenty per cent. larger than the

Erie, but our lockage exceeds hers by nearly 2000 feet. Put the extra size of our work and the shorter distance by 100 miles, and you can get a given number of bushels of wheat from Pittsburgh to *Waremouth* as cheaply and as soon by our work as you can get an equal quantity from Buffalo to New York. Now why should not this work be built? The New York work is a State institution. Why not make this a State or National institution? Its functions are national, as much so as the Ohio river, the Mississippi, or the lakes are national as great avenues for the use of all the States through which they pass.

Its cost is objected. But compare that cost to the cost of any railway fulfilling the same ends, and this work will be found to cost less, represent less capital by fully one hundred millions, than any of the great railways. Take any one of them, and from New York to the lakes, or from New York to the Ohio, which of them does not stand their owners in, in a sum less in the aggregate than one hundred and thirty or forty millions of dollars? So the work before us will cost less, by one hundred millions, than almost any one of our trunk roads. The roads may reply that their hundreds of millions have made hundreds of miles of western connection. But suppose the Ohio to be made navigable *en permanence*, and the other water extensions now progressing be carried out. Here are on the side of the canal thousands of miles of connection permeating the whole valley of the Mississippi. And see what we can do. We talk in our water estimate of 150 lockages in a day, a business which has been far surpassed on canals already. Suppose one half of these should be fully loaded boats of 280 tons each, $280 \times 75 = 21{,}000$ tons. This, on a railway, would require 2,100 cars of thirty feet long each, which train, with its locomotive, would exceed twelve miles in length, whilst the boats, in a string, would not exceed a mile and a half.

It would be easy to pursue this calculation and to show that even the rolling stock of a road, doing a rival business to this work, would require, when thrown idle, almost as much track as the thoroughfare of the road itself. The Erie train of cars and locomotives exceed one hundred miles in length now. But figures like this have been made before, and the day of canals has not yet returned. It seems almost as if affairs of this nature, which would appear specially to belong to the domain of figures, are settled more in the way that the fashions of the *beau monde* are settled. Some grand Llama, some bellwether, some Worth leads the way, and the rest follow, nay, though the leader should leap down a precipice or attempt to cross Niagara at too short a distance above the falls.

It remains now for me to try to give an idea of the style of the work, and we will commence at the east.

Style of the Work.

The better opinion amongst hydraulic engineers leans of late unquestionably to the side of slack-water (lock and dam) navigation, where that system can be adopted, and the work, then, will be a slack-water navigation,

with the exception of the mountain division from a point on the Conemaugh east to Frankstown or Hollidaysburg. There are, as has been seen, two short deviations on the Conemaugh, between Johnstown and the point where the navigation arrives at that stream from the tunnel. There is, however, another very large exception, and that is the whole of the first and second sections of the eastern division, or, say, from the mouth of the Susquehanna to the mouth of the Juniata.

In a very few words I will give some of the prominent reasons in favor of slack-water. The first is, that the expanse of water in the lock and dam system, through which the vessels pass, is indefinite, and is as large as possible, thereby easing traction, a matter of very great importance on several accounts. The second is, that in the case of slack-water the navigated water is at the lowest surface of the country, so there cannot be any leakage, except at the mechanical structures, and this latter can be reduced to a very small percentage, for of late years skill in construction almost abolishes danger from this source.

The objection to slack-water is that in times of freshet it is dangerous and difficult of navigation against the stream. In a system like ours, however, this danger is ameliorated by the number of reservoirs near our summit level, which will unquestionably reduce the freshets to some extent, and regulate and shorten their duration. This, however, always remains an objection to slack-water, but it seems to be less feared of late years than formerly. Its casual interruptions are perhaps more than made up by the additional facility of navigation which the large expanses of water afford during the quiet, medium, and low water stages.

Eastern Division.

But on a portion of the eastern division of this work the state of things is somewhat unusual. The stream to be navigated is very wide, and there is a great fall in it. From Havre-de-Grace to Columbia the rise is over two hundred and twenty-six feet, the distance being forty-five miles.

Now, dams in such a stream as the Susquehanna, in width from half a mile to a mile and over, ought not to be more than, say, from fifteen to twenty feet high; and of such dams, to make a navigation between these points, there would be required at least twenty. These, with their locks, would be costly, averaging nearly half a million each. Besides, the Susquehanna is subject occasionally to ice freshets, and when it is stated that one of these is known to have formed a dam of ice actually backing the water so as to float away a bridge which was placed at an elevation not less than forty feet, according to my recollection, above low water, some idea of their magnitude may be formed.* Yet, notwithstanding this, if as many dams as were required for this work were constructed, they themselves might prevent the recurrence of these gorges. But the subject requires more consideration than on such an examination as this I have been able

* Burr's celebrated bridge near McCall's Ferry, carried off in 1818.

to give it, nor need these considerations be brought forward until the work is nearer construction than it is.

There are many very important arguments on both sides, and all engineers know that great hydrographic questions cannot be decided without a study of the subject on the spot. Abstract science cannot settle such questions, so I will not now undertake to decide.

But this I do know, namely, that an independent canal can be made between the points in question, with one short interval of slack-water from Chicques (Chicquesalonga) gap to the foot of the Kanawaga falls, and for the present I shall return an estimate of the cost of such a work, presuming that the slack-water system throughout, on account of the unusual width of the Susquehanna, would cost about twenty-five per cent. more.

A dam at Chicques will easily supply a canal to Havre-de-Grace, though the distance is some forty-eight miles, one or two side streams being available as subsidiary supplies, and the same dam will make a slack-water to Kanawaga falls. Thence independent canal is practicable to the mouth of the Juniata, where may come in another feeder from Clark's Ferry dam, which I have presumed in the estimate will still be standing when this work comes to be further considered. From this point to the foot of the mountains about Hollidaysburg, the Juniata will be slack-watered, and this completes what we call the eastern division; its first and second sections extending from Havre-de-Grace to the mouth of the Juniata; its third embracing the Juniata to the mountain's foot.

Mountain Division.

Then comes the mountain division, commencing at Frankstown and ending at Johnstown.

This may be called independent canal for the whole way, except some pieces of slack-water on the Conemaugh before mentioned. In this division occurs the tunnel, very many locks, and some eighteen reservoirs, all shown on the map and estimates. The lockage, divided by ten, will, in general, give the number of locks, though that number may be a little exceeded where a change in the proportion cannot be avoided. This is the life and soul of the work. The tunnel has been described, area 28×42 feet. It is believed that it will mostly stand without arching; but arching is estimated for about one fifth of the tunnel's length. There is enough water, aided, of course, by the reservoirs at the summit level (the tunnel;) but if help is wanted on the slopes east and west, it can be had from the main Juniata and from branches of the Conemaugh, outside of our chosen rainfall area. For this help I don't consider an estimate necessary. In the nature of a necessity it may be considered *paulo post futurum.*

Both east and west of the mountain division, as the navigation is along the bottom of the country, toward which all the water of the region tends, there can be no leakage, and if the mountain division wants no more water, how can these valley divisions want it, receiving, as they do, all the water

saved in the mountain reservoirs, and all the waters of the valley occupied and its tributary water-sheds.

Western Division.

The western division extends from Johnstown to Pittsburgh, along the Conemaugh and the Kiskiminetas to the mouth of the latter stream. The width of the slack-watered streams will be from, say, two hundred feet at Johnstown to from five hundred to six hundred feet toward the mouth of the Kiskiminetas, and in the Allegheny from eight hundred to eleven hundred feet.

We have calculated on slack-watering the Allegheny river on the scale necessary for this work. If that river is to be improved *per se*, might not this circumstance be borne in mind, and would it not be better to calculate on the possibility of our water-way being finally constructed?

I conclude this report with the estimates, which are as follows in the tables, and the divisions are distinctly marked on the map and the profile; a map and profile on a large scale, and a sketch and profile on a small scale being returned with this report.

The summit or mountain division was actually surveyed. We ran a line with the compass and chain, inclosing one hundred and five square miles, heretofore mentioned. We ran a girt line of levels with the aneroid barometer, and, having frequent means of testing our levels upon points the elevations of which were actually known, we may state with confidence that our aneroid's errors may be all found within a zone of ten feet vertical thickness—quite near enough for a reconnaisance.

The rest of our work was amongst the archives of Pennsylvania, and as one or other of the corps had traced every foot of ground between Pittsburgh and Havre-de-Grace, we think we have been able to submit a praeticable plan and a reliable estimate. The special works of the great line we have enumerated and estimated, but not located with precision, except vertically. It would take a very careful location survey to say exactly where each of the works should be placed. Had it not been for the archives, we could have only pronounced on the possibility of this grand enterprise. With their aid we can not only say that it is practicable, but we believe it could be let to-morrow and built at our estimate. Whether it would be worth the money is for the consideration of the people. Its capacity to transport would nearly reach, if not exceed, ten million tons per annum. Put it at five million tons through trade, and one quarter of a cent per ton per mile would pay six per cent. on a cost of $40,000,000, and leave $2,000,000 to pay for keeping up the works and its management, which would appear ample.*

And ought any work to pay more profit than that and do justice to the people in the matter of transportation? A quarter of a cent per ton per mile, let that be called the inevitable first cost of transportion, leaving the

*The Erie canal transported over five million tons last year, and did not cost $1,000,000 to keep up—scarcely more than three fourths of a million.

other three fourths of a cent to reward the transporters. To this complexion must we come at last. Our farmers, producers, merchants, ought all to be able to make their bargains where transportation was an element of the transaction, estimating transportation at the rate of one cent per ton per mile for everything; but as there must be exceptions to all rules, let there be exceptions here, slightly favoring, say the heavy minerals, coal, iron, fire-clay, salt, stone, etc.

Can any railway in the United States, or elsewhere, come down to these figures and wish the system to continue long? That they have "been there," I believe, but when they were there, there must have been "hedging" of some kind or other, *Exempli gratia.* A man pays on a railway three cents per man per mile; put ten men, including baggage, to the ton, and this living freight, a freight that "handles" itself cheaper even than rolling freight, at least to the extent of two thirds of its weight, men, women, and children load and unload themselves, except the baggage, and three cents per man per mile becomes thirty cents per ton per mile. A ton of men then pays thirty times the freight of a ton of coal, when that article is carried at one cent, which, in some cases, it is. This inverse proportion of charges to the case of handling may convey a meaning of the brokers' phrase, "hedging," and helps the railways as against the canals. But as a free people, dare we not "come to think of it," try to have this piece of injustice corrected? Why is the easiest of all freight to handle to be charged at rate of three thousand per cent. higher than the inert minerals of the earth pay? True, you want higher velocities, more costly vehicles, higher priced conductors, but could not all this be managed a little short of thirty times the cost of the black diamond carriage? But to go on with the argument would take too much time; perhaps I have gone too far already; I only wished to go far enough to set others to thinking and finish out the train of thought and reasoning for themselves.

Attached to the estimate will be found a table of the reservoirs and their capacities. It will be seen that they are located on well-known watercourses, no dry ravines, but drains made in the mountain itself by nature, and of such a character in size as to have acquired a regular designation as a water course of the country. These streams are never entirely dry; there is in the greatest droughts, an appreciable amount of water in them. There can be no doubt on the subject of water, in the minds of those who are aware of what has already been done in this way, and who know the wants of a canal, not perhaps in this country, but in Europe, particularly on the continent, where, for water-ways and for great manufacturing establishments, water has been studied and practiced with, to an extent far beyond anything of the kind that has been even thought of among ourselves.

Before closing I must allude to my assistants in the field, Mr. W. H. Snyder of Centre county, in command, and Mr. Charles A. Young of Philadelphia, in charge of the levels and the aneroid. They both of them performed their parts well. Mr. H. Alricks, Jr., of Harrisburg, has as-

sisted Mr. Snyder in the mapping, and, bearing in mind that they were obliged to derive much of their data from musty archives, they deserve credit for their research.

To gentlemen in Cambria and Blair counties I am very much indebted for local topographical information; to Mr. Hutchinson of Altoona; to Messrs. Fulton, Peeler and Brawley of the Cambria Iron Company; to Mr. Antes Snyder of the Pennsylvania railroad engineer corps, and to Captain Kelly of Apollo, on the Kiskiminetas; also to Mr. Gibboney and Mr. Irvine of Duncansville, Blair county; also to gentlemen of Hollidaysburg, namely: Judge Caldwell, Mr. Jack and Mr. Gardner, and to Lawyer Hewit, but especially to Mr. D. K. Reamey, who was indefatigable in serving the little corps in every way that he could, both by his local knowledge, which is quite extensive, and acting as a guide in several cases in the mountain passes. I trust that the hopes of these gentlemen may at last be fulfilled, and that they may repossess one of our great lines of communication, which never ought to have been taken away from them. Nor would they have been deprived of it had the advice of as worthy a board of canal commissioners as ever served our Commonwealth been followed, whose majority was composed of James Clark and Jacob Holgate, names that should not be suffered to fall out of the catalogue of old Pennsylvania's notables.

I am, very respectfully,

Your obedient servant,

JAMES WORRALL, *E. C.*,

Assistant.

To Major W. E. MERRILL,

U. S. Corps of Engineers, Cincinnati, Ohio.

ESTIMATE

Showing the cost of a water-line through Pennsylvania and part of Maryland, by way of the Allegheny, the Kiskiminetas, the Conemaugh, the Juniata rivers and the river Susquehanna to Chesapeake bay, at Havre de-Grace, Maryland. The result of a reconnaissance made in the year 1878–9, under the charge of Bt. Col. W. E. Merrill, U. S. Engineers, by James Worrall, C. E. Assistant, of Pennsylvania, as follows:

EASTERN DIVISION.

First section. Havre-de-Grace to foot Kanewago Falls:		
237,600 lineal feet, enlarged canal, @ $8,	$1,900,800	
10,560 lineal feet, independent canal, @ $10,	105,600	
Dam and guard-lock at Chiques,	300,000	
60,440 lineal feet, towing path, @ $2,	120,880	
261 vertical feet, lockage, @ $2,500 per foot,	652,500	
Contingent works, bridges, &c.,	154,220	
Amount,		$3,234,000
Second section. Kanewago Falls to mouth of the Juniata:		
154,100 lineal feet, independent canal, @ $10,	$1,541,000	
82 vertical feet, lockage, @ $2,500 per foot,	205,000	
Dam with guard-lock and feeder at mouth Juniata,	150,000	
Contingent works, bridges, &c.,	95,000	
Amount,		$1,991,000
Third section. Mouth Juniata to Frankstown:		
Slack-water navigation, 57 dams @ $43,650 each,	$2,488,050	
661,700 lineal feet, towing path, @ $2 per foot,	1,323,400	
569 vertical feet, lockage, @ $2,500 per foot,	1,422,500	
Contingent works, bridges, &c.,	261,050	
Amount,		$5,495,000

SUMMARY.

First section,	$3,234,000
Second section,	1,991,000
Third section,	5,495,000
Total,	$10,720,000

MOUNTAIN DIVISION.

First section. Frankstown to east end tunnel:

64,000 lineal feet, independent canal, @ $10 per foot,	$640,000	
788 vertical feet, lockage, @ $2,500 per foot,	1,970,000	
Contingent works, bridges, &c.,	150,000	
Amount,		$2,760,000

Second section. Tunnel, reservoirs, &c.:

1,215,650 cubic yards tunneling, @ $5,	$6,078,250	
Excavation of approaches,	91,600	
28,100 cubic yards brick arching, @ $10 per cubic yard,	281,000	
One shaft, 10 feet diameter, 850 feet deep, @ $30 per foot,	25,500	
Contingent expenses,	323,650	
Amount,		$6,800,000

RESERVOIRS.	Cubic yards, at 35 cents per yard.	Outlet.	By wash.	Clearing, at $150 per acre.	AMOUNT.
				Acres.	
Yellow creek,	451,000	$12,500	$2,500	40	$178,850
South Fork,	498,000	12,500	2,500	130	208,800
Laurel run,	590,000	12,500	2,500	250	259,000
Trout run,	325,000	25,000	5,000	50	151,250
Souman run,	88,750	12,500	2,500	12	47,862
Ben's creek,	380,000	12,500	2,500	34	153,100
Conemaugh,	68,500	12,500	2,500	30	43,475
Oak run,	310,000	12,500	2,500	60	132,500
Munster run,	404,000	12,500	2,500	134	176,500
Sugar run,	337,000	12,500	2,500	20	135,950
Portage creek,	80,000	12,500	2,500	10	44,500
Adams creek,	290,000	12,500	2,500	16	118,900
Blair creek,	205,400	12,500	2,500	25	90,640
Poplar run,	385,200	12,500	2,500	20	152,820
Knob run,	280,000	12,500	2,500	30	117,500
Bulls creek,	373,000	12,500	2,500	100	160,550
Bobbs' creek,	242,000	12,500	2,500	110	116,200
For contingent expenses,					114,603
					$2,403,000

Feeders and connections of reservoirs:		
To east and west end of tunnel, 296,200 lineal feet feeder, @ $2,	$592,400	
5,300 lineal feet, pipe drift, @ $3 33⅓ per foot,	17,666	
18,000 lineal feet, iron pipe, @ $7 50 per foot,	135,000	
Clearing 570 acres, @ $150,	85,500	
For contingent expenses,	41,434	
Amount,		$872,000
Third section. West end tunnel to Johnstown:		
15,000 lineal feet, independent canal, @ $10 per foot,	$150,000	
13,000 lineal feet, independent canal, @ $12 per foot,	156,000	
Slack-water navigation, 35 dams, @ $20,000 each,	700,000	
600 lineal feet, tunnel, 26,200 cubic yards, @ $4,	104,800	
70,700 lineal feet, towing path, @ $2 per foot,	141,400	
551 vertical feet, lockage, @ $2,500 per foot,	1,377,500	
Contingent works, bridges, &c.,	142,300	
Amount,		$2,772,000

SUMMARY.

First section,	$2,760,000
Second section, tunnel,	6,800,000
Second section, reservoirs,	2,403,000
Second section, feeders,	872,000
Third section,	2,772,000
Total,	$15,607,000

WESTERN DIVISION.

First section. Johnstown to Blairsville:		
Slack-water navigation on Conemaugh, 22 dams, @ $28,000 each,	$616,000	
159,900 lineal feet, towing path, @ $2 per foot,	319,800	
219 vertical feet, lockage, @ $2,500 per foot,	547,500	
Contingent works, bridges, &c.,	74,200	
Amount,		$1,557,500
Second section. Blairsville to mouth Kiskiminitas:		
Slack-water navigation, 19 dams, @ $40,000 each,	$760,000	
230,800 lineal feet, towing path, @ $2 per foot,	461,600	
188 vertical feet, lockage, @ $2,500 per foot,	470,000	
Contingent works, bridges, &c.,	84,600	
Amount,		$1,776,200

Third section. Mouth Kiskiminitas to Pittsburgh:

Slack-water navigation, 4 dams, @ $160,000 each,	$640,000
153,200 lineal feet, towing path, @ $2 50 per foot,	383,000
42 vertical feet, lockage, @ $2,500 per foot, . . .	105,000
Contingent works, bridges, &c., ...	57,000
Amount, ...	$1,185,000

SUMMARY.

First section, ...	$1,557,500
Second section, ...	1,776,200
Third section, ...	1,185,000
Total, ...	$4,518,700

	Totals.	Lengths.
Eastern Division, ...	$10,720,000	212 miles, 5,040 feet.
Mountain Division, ...	15,607,000	36 miles, 3,220 feet.
Western Division, ...	4,518,700	103 miles, 60 feet.
Total, ...	$30,845,700	352 miles, 3,040 feet.

Lockage, Chesapeake bay to tunnel, ...	1,700 feet.
Lockage, tunnel to Pittsburgh, ...	1,000 feet.
Total lockage, ...	2,700 feet.

Statement of Reservoirs.

LOCATION.	Number of dams.	Height.	Capacity in cubic feet.
Yellow creek, west side, ...	1	80 feet	70,000,000
South Fork, "	1	80 "	190,000,000
Laurel run, "	1	80 "	246,000,000
Trout run, "	2	50 "	53,000,000
Souman run, "	1	50 "	15,000,000
Ben's creek, "	1	100 "	62,000,000
Conemaugh, "	1	45 "	23,000,000
Oak run, "	1	80 "	100,000,000
Munster run, "	1	80 "	195,000,000
Sugar run, east side, ...	1	100 "	29,000,000
Portage creek, "	1	50 "	11,000,000
Adams creek, "	1	100 "	19,000,000
Blair's creek, "	1	80 "	27,000,000
Poplar run, "	1	90 "	27,000,000
Knob run, "	1	80 "	33,000,000
Bulls creek, "	1	80 "	80,000,000
Bobbs' creek, "	1	60 "	77,000,000
	18	. . . . .	1,257,000,000

The Estimate.

It will be seen that the estimates of the different divisions amount to the sum of,	$30,845,700
Now, if we double the locks we must add,	5,400,000
Doubling a lock is not quite doubling its cost; we reduce the double 20 per cent.,	$36,245,700
It is usual to add 10 per cent, for unforeseen contingencies,	3,624,570
Making,	$39,870,270
We increase this sum by,	129,730
Which makes the round sum,	$40,000,000

An amount deemed sufficient to make a waterway of two hundred and eighty tons capacity per boat from Pittsburgh to the head of the Chesapeake bay, which sum has been used in the text of this report.

In like manner it will be seen that 352 miles+3,040 feet, or 352½ miles +400 feet, is given for the length of this work. This we have called in the body of the report three hundred and fifty-five miles; for on a line dealing with meandering streams there may well be such a margin, and this provision, too, is on the safe side. So the line may be considered to be three hundred and fifty-five miles long, and is estimated to cost $40,000,000, calculating for double locks the whole way.

This estimate is reasonable, and as we have said already, we believe the work could be let or contracted for to-morrow for that sum and finished within five years, or the time necessary to complete the tunnel. All which is respectfully submitted with the foregoing report.

A map on a scale of about eight miles to the inch; and a larger map, showing the mountain division on a scale of two thousand feet to the inch, the eastern and western divisions on a scale of ten thousand feet to the inch; will accompany this report. An outline sketch accompanies this edition of the report, the other maps being on file in the engineer department.

J. W., *Assistant.*

SUSQUEHANNA RIVER.

Letter from the Secretary of War, transmitting report of Colonel J. N. Macomb of survey of Susquehanna River, from southern boundary of New York to Nanticoke dam, Luzerne county, Pennsylvania.

WAR DEPARTMENT,
WASHINGTON CITY, *February 6, 1880.*

The Secretary of War has the honor to transmit to the United States Senate a letter from the Chief of Engineers, dated the 3d instant, and accompanying copy of report from Colonel J. N. Macomb, corps of engineers, of an examination made of the North Branch of the Susquehanna river from the southern boundary of the State of New York to the Nanticoke dam, in Luzerne county, Pennsylvania, in compliance with the provisions of the river and harbor act of March 3, 1879.

ALEXANDER RAMSEY,
Secretary of War.

The PRESIDENT *of the United States.*

OFFICE OF THE CHIEF OF ENGINEERS,
WASHINGTON, D. C., *February 3, 1880.*

SIR: To comply with the requirements of the river and harbor act of March 3, 1879, I have the honor to submit herewith a copy of a report to this office from Colonel J. N. Macomb, corps of engineers, of the results of an examination, made under his direction, of the North Branch of the Susquehanna river, from the southern boundary of the State of New York to the Nanticoke dam, in Luzerne county, Pennsylvania.

Very respectfully, your obedient servant,

H. G. WRIGHT,
Chief of Engineers, Brig. and Bvt. Maj. Gen., U. S. A.

Hon. ALEXANDER RAMSEY,
Secretary of War.

EXAMINATION OF SUSQUEHANNA RIVER.

UNITED STATES ENGINEER OFFICE,
PHILADELPHIA, PA., *January 22, 1880.*

GENERAL: The examination of the North Branch of the Susquehanna river, from the point where it enters the State of Pennsylvania, at the southern boundary of the State of New York, down to the Nantieoke dam in Luzerne county, which was called for by a provision in the second section of the river and harbor act, approved 3d March, 1879, was assigned to me by your letter of the 12th of May last.

Owing to the extent of my duties with the works on the Delaware and Atlantic coast, I was unable to give the examination much of my personal attention; but I was fortunate in securing the services of Mr. James Worrall, who is well and favorably known as one of the early civil engineers upon the public works of Pennsylvania, and to him I intrusted the examination, the result of which is set forth in his report, which I now beg leave to submit to you.

I ascertained that the immediate want of those interested in the improvement of the stretch of river above named was to have an estimate of the probable cost of securing a navigation which would accommodate boats of light draught. I therefore directed the assistant engineer to make his examination with a view to affording a depth of not exceeding 3 feet at extreme low water, and at the same time I authorized him to embody in his report such information touching the cost of improving the Susquehanna with a view to affording an additional line of navigation from the Great Lakes to the sea, and to this end he was to consult the archives of New York and Pennsylvania, and to introduce his conclusions derived from his life-long consideration of the subject incidental to his early employment upon the canals of Pennsylvania.

The engineer party during the whole time of field-work had the benefit of a remarkably low stage of water, such as had not obtained for some sixty years. This allowed of the procuring of information as to the character and extent of the obstructions which, under ordinary circumstances, could only have been obtained at a very great expense.

It will be seen by Assistant Worrall's report that the total extent of shoals requiring to be improved is about $12\frac{1}{8}$ miles, in that part of the Susquehanna specially under consideration, and that the cost of obtaining a depth of from 2 to 3 feet at low water would be about $250,000. Accompanying the report herewith submitted is a map of the portion of the Susquehanna referred to, and a sketch of the route from Buffalo to the

head of our proposed improvement, as illustrative of the through route from the Great Lakes to the sea, which may serve as affording an interesting comparison with existing routes.

All of which is respectfully submitted by your most obedient servant,

J. N. MACOMB,
Colonel of Engineers.

To the CHIEF OF ENGINEERS, U. S. A.

REPORT OF MR. JAMES WORRALL, ASSISTANT ENGINEER.

HARRISBURG, PA., *December 2, 1879.*

SIR: I have the honor to have had placed in my charge, in the latter part of this year, a reconnaissance of the North Branch of the river Susquehanna from the Nanticoke dam, seven miles below Wilkes-Barre, to the State line between New York and Pennsylvania, with the view to its adaptation to a continuous navigation as deep as the nature of the case will admit, and I have taken great pleasure in the performance of the duty, the more especially as I am required to report the facts to yourself.

The amount appropriated to meet the cost of this examination was very small, but it must be some gratification to the people of New York, Pennsylvania, and Maryland, its riparian inhabitants, to know that their great river has even partially attracted the attention of the general government. That the Susquehanna is a national stream, I think, need hardly be questioned. Heading by several branches far up into the State of New York, and draining a most productive mineral and agricultural country, it passes entirely through Pennsylvania from north to south, but meandering so as to embrace a very large portion of her territory, it falls into the Chesapeake Bay, after having passed through Maryland in a similar manner. It drains with its branches fully three-fifths of the area of the great State of Pennsylvania, and in the early day deposited vast quantities of the productive wealth of that grand old State on the wharves of Baltimore, a circumstance which must have helped materially in the incipient growth of that prosperous city; and, indeed, if Pennsylvania had not early seen to it that the great valley was tapped at various points by highways leading toward the city of Philadelphia, Baltimore must have attained a large monopoly of the productive wealth of the valley under consideration. When William Penn first brought his charter across the sea and examined the topography of the territory granted to him, he discovered how easy it would be for the products of his magnificent plat of land to gravitate toward the southern waters; his fears afterwards having been partaken of by the most prominent of the Pennsylvanians, amongst whom Franklin and Rittenhouse stood pre-eminent, Franklin fearing the result even to the day of his death, for in his will he left a very considerable sum toward the construction of a water-way from the interior and from the lakes to the city of Philadelphia.

The Schuylkill and the Union Canals, the Pennsylvania turnpike, the Columbia Railroad, and finally, the great Pennsylvania Railroad, were all built for the purpose of directing trade from its natural destination by the river Susquehanna to Baltimore. None of these were built too soon, and, even to this day, if the trade gravitating southward from Pennsylvania to

the Chesapeake waters and their port of Baltimore, were entirely diverted northward, that great city would feel the deprivation most seriously. Who shall say then that the river Susquehanna is not a national river, and worthy of the attention of the general government? But to improve it now as a highway, *per se*, no longer affects the trade of the city of Philadelphia injuriously.

Tapped as it is so very frequently, every few miles indeed, by railways leading to the valley of the Delaware, there is no danger of withdrawing from Philadelphia any portion of the trade to which she can show her natural and just claim.

State competition has little to say as to the creation of grand ways through this nation, embracing as it does almost a continent. Let them all be opened and let transit along them be facilitated. It is the duty of the general government to see to it now, that the people of all portions of the Union shall get to the ocean by the most convenient route and leave it to themselves to choose their markets. There is no longer any necessity for petty State jealousies on this subject. Nay, if the physical geography of the country presents an easy route from an average point in the productive West to a favored point on the seaboard, let that point be any one of the great cities from Boston to New Orleans. then let that route be improved, be the merely local consequences what they may.

The whole people must be accomodated by the improvement of the natural facilities of the whole territory. Let this be done by the aid of the general government; it is a ' regulation of commerce " provided for with supreme wisdom by the framers of the Constitution. That upon closer examination the Susquehanna will be found to be a route for a national highway there can be no question. It offers facilities for the delivery of corn, iron, coal, oil, and the other immeasurable products of our hills and valleys. Passing through three great States in which the three greatest cities of the country are located, the products of the valley can be delivered at either of the three almost indifferently as there may be demand for them, and it should be improved, then, to its utmost capacity.

The Susquehanna is a national stream, can be made a national highway, can connect equally well with the Ohio and the lakes, is perhaps the best connection of those great sources of wealth with the Atlantic Ocean. Let the connection be commenced, even on the smallest scale; if it possesses the merit claimed for it the final enlargement will come in the course of time. All that is asked for now is the improvement of one of its branches from a point to which it is already accommodated by an extremely well-managed canal.

Canal communication already exists from Havre-de-Grace, the mouth of the Susquehanna. to Wilkes-Barre, a distance of about 190 miles. Here the greatest economy of transportation is practiced. Coal is transported over this canal at a cost of considerably less than a half a cent per ton per mile, giving the assurance that that measure of cost may eventually be applied

universally for all products where water communication can be established, and eventually guaranteeing a general reduction on railways to that figure, or a figure as near to it as they can stand.

It is not asked that the North Branch of the Susquehanna shall be immediately canalized. An improvement of its bed is all that is asked for at present, and that to a very small extent. From Wilkes-Barre toward the New York State line, the country is pre-eminently alluvial. The old sedimentary rocks remain undisturbed and lie as they were deposited in level stratification. All the valleys have evidently been eroded, the inclination of the streams is gentle, or if there is a fall it is often a step from one level to the next below. Or, as in the case of the river, the stream moves along a gentle declivity scarcely greater on the average than at the rate of two feet to the mile.

The bottom of the North Branch consists from Wilkes-Barre up, of a series of ponds and ripples; the ponds are often quite deep and extend for miles. The ripples are for the most part very short and have a fall of but a few inches, not often reaching two feet and seldom exceeding it.

In the early day when the Connecticut people first settled in the valley, Durham boats were used for the transportation of freight for quite long distances, a very slight rise in the river sufficing to make the navigation continuous. Of late years it has been considered worth while to place small steamboats on these long ponds, which perform the transportation of persons and things quite regularly. It is a navigation to accommodate such steamers that is at present asked for, and it really, upon examination, seems to be a cheap and easy matter to afford it. It is true that the improvement of the bottom of a stream has always been considered an extremely difficult matter to accomplish, and there are very many streams on which, indeed, it may be pronounced impossible. But it is believed there are cases which can be managed, and this is one of them. At least it would be well worth trying the experiment here, for if here it should succeed it may eventually be adopted on the Ohio, as it is a fact that the beds of the Ohio and of the North Branch very much resemble each other, a gentle average fall, a gravel bottom, a series of ponds and ripples, the ripples generally being quite short. Here the experiment could be tried much better than on the Ohio, for here there is no great traffic to interrupt, as would be the case on the Western streams, and as the ratio of fall is greater here than on the Ohio, success here would be *a fortiori* in favor of success on the Ohio. The plan proposed is a very old one and a very new one. It is believed to have been used on the Euphrates in the times when Babylon and Nineveh flourished, and it is used at the mouths and in the valleys of several important rivers in Europe at the present moment, whilst it is believed to be in the full tide of successful experiment at the mouth of the Mississippi, under the superintendence of Captain Eads. It is simply the system of jetties, the only system that ever has succeeded in making a stream at certain points deeper than nature had originally made it. Cutting through a bar, except by means of the current itself, has invariably failed.

The utmost depth that is asked for here is three feet, and if three feet cannot be attained, then two feet will be gladly accepted.

After a careful examination of very many of the bars, it does seem to me that an application of the jetty and wing-dam system here might produce at least a navigation two feet deep with the possibility of three feet. The jetty system has been lately so much talked of that it seems hardly necessary to explain it. It is indeed nothing more than a reduction of the cross-section of the stream in width, hoping thereby to increase the depth, or by increasing the current until it will scour down the bottom.

This is all that ever has been done in this direction, and is believed to be all that ever can be done. To affect the object requires great judgment in the engineer. Every ripple has its own peculiar regimen, which is either uniform or variable. Every ripple, then, must be studied with the utmost care until its habit be thoroughly understood, and then the proper remedy applied. The remedy in this case, however, cannot be costly. A few hundred feet of cribs, filled with stone, judiciously placed, will answer the purpose, and these cribs need never be more than 5 feet in depth by from 10 to 12 feet in width.

Place these where they ought to be, and some phenomena will result; if that result be to deepen the current and not too much increase its velocity, the end is accomplished. The system will be self-acting and will last until the friction of the water wears out the timber of the cribs, a period quite sufficiently long in this case; for before it is reached the valley of the North Branch will be a water-way of the first class from the lakes to the sea—a branch of the Erie Canal through Pennsylvania.

The present use of this proposed navigation would be to accommodate the inhabitants living along the North Branch for the transportation of their products. The length to be accommodated, without counting branches which may be brought in, may be stated at about 117 miles. The inhabitants deriving benefit may reach from 100,000 to 200,000, or to a still greater number. The products will be coal, iron, oil, and the cereals. It will be seen before this report is completed that the small sum of $250,000 will nearly, if not quite, effect the object, and the system once established, if the work be well done, will scarcely require supervision.

The method of transportation would be by boats not drawing more than two feet of water, towed by steam tugs of equally shallow draft. If this thing can be done is it not a work for the general government?

Is it not a regulation of commerce between the States? Are not the States of New York, Pennsylvania, and Maryland a respectable branch of this great nationality? Has not the government already done things less strictly national than this? I have had notes taken by a competent young engineer, Mr. H. Ahrieks, junior, of Harrisburg, assisted by an experienced old pilot, Mr. P. W. Redfield, of Tunkhannock, of the stream of the North Branch, from the boundary line of Pennsylvania and New York to the Nantieoke dam, who have examined and sounded the ripples and those of

the ponds which an 8-foot rod would reach, and I find them in aggregate length about 64,000 feet or $12\frac{1}{8}$ miles, nearly. These at, say $20,000 per mile when arranged, would cost in the aggregate $242,500, or say, in round numbers, $250,000. Ought not this work at least be commenced and the experiment tried? Nothing of moment has ever been done for the great river Susquehanna by the government. Is it not time to recognize the claims of Pennsylvania in her regard?

But the system of navigation proposed above is very far indeed from what may be effected through the magnificent valleys of that stream.

A few years ago, during General Grant's second term, the subject of water-ways—national water-ways—was suggested in one of his messages. A committee was raised in the United States Senate, of which Mr. Windom, of Minnesota, was chairman, and the subject was in that committee carefully studied out and reported upon. The writer of this report took the liberty of suggesting to the committee the route for water-ways through Pennsylvania, and with the aid of General Cameron, who is known to have always taken a deep interest in these matters so important to his State, the suggestions of the writer were brought before the committee, which suggestions were treated with great courtesy by the distinguished chairman.

The great Pennsylvania routes were all pointed out and their characteristics summarily alluded to. They were as follows:

First. A route from Pittsburgh by the Allegheny Valley, the Kiskiminetas, and Conemaugh, with a 5-mile tunnel through the summit of the Allegheny mountain, the Juniata, and the Susquehanna to its mouth.

Second. A route by the Allegheny Valley, Red Bank, or a parallel stream, the Sinnemahoning, the West Branch of the Susquehanna, to Northumberland, and thence by the main stream to its mouth, this being capable of variation by the Kiskiminetas and Black Lick.

Third. A route from Buffalo, using the Erie canal for about 150 miles, to Montezuma, and thence, via Seneca Lake and the Chemung canal route, to Elmira, thence by the Chemung and the valley of the North Branch of the Susquehanna, to Northumberland, and thence, by the same route as No. 2, to the mouth.

It so happened that in the fall of the year 1878, I was called upon to verify my assertions with regard to the Kiskiminetas route, reporting to Brevet Colonel W. E. Merrill, United States engineers. In this report a plan was developed for a canal route from Pittsburgh to the Chesapeake Bay, the length being 355 miles, and the cost $40,000,000. I alluded to the other lines, but the portions of the report not strictly belonging to the Kiskiminetas route were not printed. I have thus projected a water route which I consider entirely practicable from the valley of the Ohio at Pittsburgh to tide-water. This, however, was not original with me, but had been previously approved by the very highest engineering authority. I am now called upon to report upon a portion of a line which can be produced east and west so as to form another entirely practicable route from the lakes at Buffalo to the same point on tide-water, both passing for the most

part through Pennsylvania, so that Pennsylvania is entered as a claimant for consideration whenever hereafter the subject of great water-ways shall come up for consideration by the general government, as possessing:

1. A line quite equal to any other from the lakes to the sea.
2. A line superior to any other from the Upper Ohio to the sea.

The lake line is scarcely longer than the Erie canal route, which, of course, includes the Hudson river from Albany to the sea, the latter being in round numbers somewhat in excess of 500 miles.

The line from the Ohio to the sea is identical in length with the Erie canal to Albany. The present size proposed is for a lock of 120x20 feet, seven feet water, the canal prism being 70 feet wide on bottom, seven feet deep, with slopes in earth of two to one, the burden of boats being 280 tons. The lake route through Pennsylvania cannot be varied. The Ohio valley route may reach the waters of the main Susquehanna as has been seen by a choice of routes. A map and profile of the lake route will be shortly submitted, being now in preparation, showing the location of the line from Havre-de-Grace, the mouth of the Susquehanna, to Elmira, and upon the same sheet is shown, upon a different scale, the proposed improvement in map and profile from Elmira to Buffalo, the line of the Chemung canal, Seneca lake, and the Erie canal, as has been stated, from Montezuma to Buffalo.

For most of the information submitted in this report I am indebted to the State archives, both of New York and Pennsylvania, which proved to be richer as resources than had been originally anticipated, although every mile of all the lines spoken of has been passed over by me or surveyed under my direction. At Elmira I had expected that a considerable amount of hydrographic measurement would be required; but upon a contemplation of the Chemung river at that place, although I made some measurements of the quantity of water at its average low stage, inspection alone convinced me that the amount of water attainable on the Upper Chemung was, and would prove ample, possibly without the aid of reservoirs; with that aid unquestionably so.

As compared with the Erie canal the Pennsylvania line will have the disadvantage of between 400 and 500 feet of extra elevation, necessitating some 80 or 90 locks in addition, but with the advantage of Seneca lake and slack-water navigation from Elmira to Columbia (about 250 miles in the aggregate,) affording an indefinite expanse of water in which the boats would move or be towed as against nearly 200 miles of close canal on the Erie, the period of a voyage from Buffalo to tide-water by the southern route would hardly be longer than that required for a voyage by the northern one. The estimate is as follows:

First. For improving the North Branch of the Susquehanna from, say, Wilkes-Barre to the State line, to afford a steam navigation, two feet in depth, continuous and permanent, .	$242,500
Contingencies, ...	7,500
	$250,000

Second. Calculated upon information derived from State archives and former reports for a 280-ton navigation from Havre-de-Grace to Buffalo:

a. From Havre-de-Grace to the mouth of the Juniata, 87 miles,	$5,747,500
b. From the mouth of the Juniata to Northumberland, 38 miles,	3,800,000
c. From Northumberland to Nanticoke dam, 56 miles,	1,120,000
d. From Nanticoke dam to mouth of Chemung, 110 miles,	2,200,000
e. From mouth of Chemung to Elmira, 18 miles,	440,000
f. Elmira summit feeders, &c., to first lock on Chemung canal, 12 miles,	790,000
g. From first lock on Chemung canal to Seneca Lake, 11 miles,	1,500,000
h. Seneca lake, 37 miles,	0,000,000
i. Seneca lake to Montezuma, 23 miles,	550,000
k. Montezuma to Buffalo, 156 miles,*	1,500,000
548 miles in all,	$17,647,500
Add for doubling the locks,	4,020,000
	$21,667,500
Add the usual 10 per cent.,	2,166,750
	$23,834,250
Add for the uncertainty of a reconnaissance,	1,165,750
Total,	$25,000,000

Thus we reach for this new grand water-way joining the Erie canal with the Chesapeake Bay, the sum of twenty-five millions, which sum, I have stated in conversations for many years back, would cover the cost, and I now believe that contractors can be found with capital in the United States who would take the work at the figure stated, and upon the datum of this report alone would give ample security for its completion. The distance from Buffalo to tide by this without correction is 548 miles, but it is believed that close and careful engineering would reduce that above 24 miles, making it about 20 to 25 miles farther from Buffalo to Havre-de-Grace than to the city of New York. But for trade or freight bound from the lakes to foreign southern ports this would be a great advantage; and looking forward to man's work in the next century, which will be in its fullest activity in the Mediterranean, whether it be in the settlement of the eastern question or the colonization of Africa, it would be an advantage to turn these lake freights in a southern direction. The general average facility of navigating this water-way may attain for its boats a velocity which would make up for the difference in distance.

I now recapitulate the facts of this report in answer to my instructions to make a reconnaissance of the North Branch of the river Susquehanna

* It is presumed that much of the enlargement of the canal prism of this division is or will be completed by the State of New York to the projected size.

from Nantieoke dam to a point at or near the New York State line, with permission to make other suggestions legitimately growing out of the subjeet.

1. From Nantieoke dam to the State line the distance is about one hundred and seventeen miles, of whieh about one hundred miles are already navigable; but are interrupted by ripples, the aggregate length of whieh somewhat exeeeds twelve miles, whieh have been estimated. These ripples, I believe, ean be eorreeted, and a continuous navigation of at least two feet, and perhaps three feet, in minimum depth ean be established for the gross sum of $250,000.

2. An enlargement of the locks of the Erie eanal, from Buffalo to Montezuma, so as to pass boats of two hundred and eighty tons, and a braneh of the same from Montezuma through Elmira, N. Y., and Northumberland, Pa., to Havre-de-Grace, Maryland, ean be built to aeeommodate the same tonnage for $25,000,000.

A map and profile will aecompany this report as before mentioned, and with the map there will be a statement of the usual details of distances, elevations, &e.; also the position of a majority of the ripples to be treated between Nantieoke dam and the mouth of the Chemung.

I am, very respeetfully, your obedient servant,

JAMES WORRALL,
C. E. Assistant.

Col. J. N. MACOMB,
Corps of Engineers, U. S. A.

Report of Mr. H. Alricks, Jr., Assistant Engineer.

HARRISBURG, PA., *December 1, 1879.*

SIR: Aecording to instructions reeeived from you on Oetober 8, 1879, I proeeeded to the vieinity of Athens, at the junetion of the Chemung and North Braneh of Susquehanna rivers, and aeeompanied by a pilot, P. W. Redfield, of Tunkhannock, Pa., and oarsman, eame down the river to Plymouth, above Nanticoke dam, in a row-boat, noting the eontours and sounding the river, and estimating the width and length of shoals at all plaees where the depth of water did not exeeed two feet. The unusual shallowness and limpidity of the water at that time made the result of sounding much more aeeurate than if it had been deeper or muddy. The following table will give the result in detail. The distanees given are from the stations or towns preeeding, and in the same eolumns as said distances, as I was able, by this method, to eheek my estimated distanees by those of the railroad. The map accompanying, whieh I made under your direetions, will explain itself.

Stations and distances.	Character of shoals.	Depth of water.	Estimated length of shoals.	Characteristics of stream.	Local designation of shoal or vicinity.	Remarks.
Athens:		*Inches.*				
600 feet,	Loose stone and gravel,	18	40 feet,	30 feet wide,		One small bar between here and State line.
1,000 feet,	do. do.	18	500 feet.			
1 mile,	Gravel,	18	1,000 feet.			
1¼ miles,	Large gravel,	8	30 feet,	120 feet wide,		Gravel shoals.
1¾ miles,	Broken rocks,	18	20 feet,			Rocky shoals; seems as if site of old dam.
2½ miles,	Loose stones,	24	100 feet,	200 feet wide.		
3 miles,	do.	18	300 feet.			
3⅓ miles,	do.	18	150 feet.			
3¾ miles,	do.	18	50 feet,			Island to right.
4 miles,	Large, loose bowlders,	12	800 feet,			Shoals.
4½ miles,	Loose stone and gravel,	20	600 feet,	300 feet wide.		
4¾ miles,	do. do.	18	600 feet.			
4⅞ miles,	Large scattering rock and egg-sized stones.	18 to 20	400 feet,			Island to right.
6 miles,	Loose, small stone and rock,	19	50 feet.			
6⅛ miles,	do. do.	18	30 feet,	150 feet wide.		
7⅛ miles,	do. do.	15	70 feet,			Cash's creek.
8 miles.						
Ulster:						
¼ mile,	Loose, round stone,	8 to 18	50 feet,		Ulster ripples.	
½ mile,	Loose stone and gravel,	16	200 feet.			
⅞ mile,	Loose rocks,	15 to 20	400 feet,	120 feet wide,		Very swift; fall 2 feet in 200.
1⅛ miles,						Old dam; 2½ feet fall.
3 miles.	Loose stone, rock, and gravel,	15	50 feet,	100 feet wide,	Sugar creek island ripples,	Abrupt fall of 15 inches.
7⅓ miles,	do. do.	10 to 15	140 feet.			
7¾ miles,	do. do.	8 to 12	120 feet,	150 feet wide.		
8½ miles,	Deep water,			Narrow and swift.		
4 miles,	Small stones, gravel, and sand,	16 to 22	600 feet.			
4½ miles,					Sugar creek shoals,	Sugar creek enters on right.
5¾ miles,	Loose, flat, and broken rocks,	10 to 20	75 feet.			
6 miles,	Loose stone,	20	300 feet,	400 feet wide,		Lehigh Valley railroad bridge.
6⅝ miles,	do.	20	600 feet.			
7 miles,		22	20 feet.			
Towanda,	Gravel and egg-sized stones,	4	30 feet,			Numerous sand bars opposite town.
1,000 feet,				300ft wd.; very deep		Remains of old river dam.
⅛ mile,	Loose rocks,	18	30 feet.			
¾ mile,	Small stones and gravel,	15	1,000 feet.			
⅞ mile,		18	1,500 feet,	60 feet wide,		Mear's island; Towando creek to right.
2½ miles,	Loose rock and stones,	18	50 feet,			Old fish dams.
4 miles,		12 to 24	500 feet,	150 feet wide,	Town of Wysanking to left,	Wysanking creek to left.

4⅛ miles,	Loose stone,	18 to 24	1,300 feet,	Rapid fall,	Head of York Narrows.	
4¼ miles,	do.	15 to 24	400 feet,	900 feet wide,		
6⅛ miles,	do.	18	30 feet,			Dam (fall of 15 inches) built of stone and boards.
6¾ miles,	do.	12	60 feet,			Fish-dam.
6⅞ miles,		8 to 36	60 feet,			Small island to left.
7 miles,	Small stones and gravel,	6 to 18	260 feet,	15 inches fall,		Shoals immediately below Standing Stone.
Standing Stone:						
⅛ mile,	Round stones,	16 to 36				Ferry.
1⅜ miles,	Large, loose rocks,	15	200 feet,		Drury Creek to right.	
1⅝ miles,					Standing Stone to right.	
3 miles,	Loose stone,	15 to 24	200 feet.			
Rummerfield,					Rummerfield Creek enters on left.	
¼ mile,		10 to 24	300 feet,	Rapid 2 feet fall,		Fish-dam.
1 mile,	Loose stone,	18	700 feet,			Old fish-dams.
2¼ miles,	Loose stone and rocks,	18	1,000 feet,		Omit's dam; 5 feet high,	Channel should be on east side of bar.
2½ miles,	Loose stone,	15 to 24	400 feet.			
3 miles,					Omit's mill and ferry,	Frenchtown to left.
4⅛ miles,	Loose, round stones, and gravel,	18	50 feet,		Dodge's Bar,	Gravel on bar said to be shifting.
6 miles,				500 feet wide.		
6⅛ miles,						Ferrytown to right.
7 miles,	Loose rocks and stones,	18	700 feet.			
8½ miles,	do. do.	12 to 36				
Wyalusing,						Wyalusing Creek to left.
½ mile,	Large rocks scattered,			Rocks about 10 cubic yards.		
¾ mile,	Loose stone,	4 to 15	200 feet.			
1 mile,						Browntown Ferry.
1¼ miles,	Loose stone,	18 to 24	800 feet,			Island to right.
1⅜ miles,	Loose stone and gravel,	4 to 18	400 feet.			
1¼ miles,						Sugar Run.
2½ miles,	Loose stone and gravel,	8 to 24	300 feet,		Sugar Run Shoals.	
4 miles,	do. do.	15 to 20	150 feet,			About 1,500 feet above point of mountain.
4¼ miles,	Loose stone,	10	300 feet,	Fall 15 inches.		
5⅜ miles,	Loose stone and gravel,	12	100 feet,			Point of mountain; county line.
5⅞ miles,	Stones, gravel, and rocks,	18	200 feet,		Wyalusing Falls,	Shoal and old fish-dam.
6 miles,	Small stones,	6 to 18	150 feet,			Shoal below falls.
10 miles.						
Laceyville,	Scattered detached rocks,	18	100 feet,	60 feet wide,	Island to left,	Fish-dam; 3 feet fall.
1 mile.						
Skinner's Eddy,	Loose, small stone,	10 to 18	150 feet,	200 feet wide,	Shoals,	Tuscarora Creek to left.
¾ mile,	do. do.	18 to 24	500 feet,			Deeper water to right.
1 mile,	Gravel and stone,	18 to 24	1,800 feet,	Shallow and swift,		
1½ miles,	Large, detached rocks,				Kinney (formerly Champion) Island.	Channel should be to left of island.
2 miles.						
Black Walnut,	Gravel and stone,	10	450 feet.			
1¼ miles,	do.	20	40 feet,	300 feet wide,	Stirling Island.	
1½ miles,	do.	6 to 15	600 feet,	Swift,	Fassit's Shoals.	

Stations and distances.	Character of shoals.	Depth of water.	Estimated length of shoals.	Characteristics of stream.	Local designation of shoal or vicinity.	REMARKS.
		Inches.				
2¼ miles,	Loose stone and rock,	10 to 20	1,400 feet.			
3 miles,	do. do.	Av. 18	400 feet.			
5 miles.						
Meshoppen,						Meshoppen Creek enters to left.
400 feet,	Loose stone and debris,	12 to 27	500 feet.			
⅝ miles,	Loose round stones,	18	800 feet,			Point of mountain to left.
3 miles,						Mehoopany to right.
Mehoopany:						
1½ miles,	Gravel, sand, and stone,	16 to 24	400 feet,			Just above old dam.
1⅝ miles,					Horse Race Falls,	Old coffer-dams, &c.
2⅜ miles,	Gravel, sand, and stone,	12	600 feet.			
2½ miles,	Loose rock and stones,			50 feet wide,	Part of Horse Race Falls: deep and swift.	Falls 4 feet; water rough.
3 miles,				do.		Falls 2 feet in 100 feet.
3⅝ miles,	Loose rock and stones,	18	400 feet,			Head of Stirling's Folly; falls about 18 inches.
500 feet,	do. do.	12 to 18	600 feet,	700 feet wide.		
6½ miles,	Rocks,	18 to 30	200 feet.			
7 miles,					Robinson's Bar.	
Vosburg,	Rocks, stone, and gravel,	10 to 18	600 feet,	Swift,	Creek to left,	Channel should be cut right of island.
⅜ mile,	Loose stone and gravel,	10 to 24	1,000 feet,			Very shallow all over river.
1¾ miles,					Teague's Creek.	
2 miles,					Teague's Eddy,	Very deep.
2⅜ miles,					Harding's Island.	
3½ miles,	Scattered rock,	10 to 24			Shoals above Tunkhannock,	Channel should go to right of island.
⅝ miles,	Stone and rocks,	15 to 36	1,100 feet,			Old fish-dam.
4¼ miles,	Loose round stones,	18	1,000 feet,			Fish-dams.
5 miles.						
Tunkhannock,						Tunkhannock Creek enters on left.
⅛ mile,	Loose stone and rock,	12 to 18	150 feet,	800 feet wide.		
2 miles,	Large, round, and small stones,	18 to 24	About 2 miles,		Swift,	Kennedy's Shoals.
2⅝ miles,	Rocky bottom,	20	do.	Ledges of solid rock; light current.	Part of Kennedy's Shoals,	One mile or more of rocks; considerable blasting necessary.
4⅛ miles,	Rocks and stones,	18 to 24		Rocky and very swift.		Opposite old lock.
5 miles.						
Lagrange,	Loose rock and stone,	18 to 20	400 feet,	200 feet wide,	Osterhaut's Bar,	Osterhaut's Creek enters to left.
¼ mile,	Small, round stones,	18 to 22	500 feet.			
1¼ miles,						Point of mountain to left.
1⅝ miles,	Loose stone, rock, and gravel,	10 to 18	800 feet,		Fiteh's Shoals.	

2¼ miles,	. . . . .	. . . .	. . . . .	Few scattered rocks.		
2⅞ miles,	Loose stones, ...	18 to 24	200 feet, ...	. . . . .	. . . . .	Old fish-dam.
3 miles, McKune's,	Loose stones and rock, ...	12 to 24	300 feet, ...	Three Brothers Islands.	. . . . .	Shoals at head of island.
3½ miles,	Rocky ledge, ...	18	50 feet, ...	Swift, ...	. . . . .	Old fish-dam.
4¼ miles,	Loose small stones, ...	16 to 20	300 feet, ...	Falls 2 feet, . . .	. . . . .	Channel should be to right of Three Brothers Islands.
6 miles.						
Falls.	. . . . .	. . . .	. . . . .	. . . . .	Buttermilk Falls.	
150 feet, . . .	Round and irregular shaped stones,	15 to 30 and 48	1,000 feet, . .	Scattering rocks,	Creek enters to left.	
¼ mile, . .	do. do.	16 to 36		Rough and rocky,	Falls Shoals, ...	Old fish-dams.
3 miles, . . .	Scattering rocks, ...	24 to 36	½ mile, ...	. . . . .	Flat Rock Shoals, ...	At this point of mountain the county lines of Wyoming, Luzerne and Lackawanna meet.
2½ miles, . .	Round stones, ...	8 to 24	1,000 feet, . . .	800 feet wide.		
3¾ miles, . .	Stones and rocks, ...	12 to 24	500 feet, ...	900 feet wide.		
4⅛ miles, .	do.	10 to 18	600 feet, ...			
5⅛ miles, . .	Loose round stones, ...	10 to 18	800 feet, ...	. . . . .	. . . . .	Point of mountain to left.
5¾ miles, . .	do.	10 to 18	800 feet, ...			
6 miles.						
Ransom, ...	. . . . .	. . . .	. . . . .	. . . . .	. . . . .	Ferry.
1 mile, . . .	Rocky, ...	15 to 48	About 1 mile.	Rocky and swift,	. . . . .	Old fish-dams.
1½ miles, .	Rocks and bowlders, ...	18 to 48		. . . . .	Saxe Falls.	
2 miles, . .	Stones and rocks, ...	10 to 20				
3 miles, . . .	Loose round stones, ...	5 to 15	600 feet, ...	. . . . .	Falling Spring Shoals, . . .	Old fish-dams.
3⅔ miles, . .	. . . . .	. . . .	. . . . .	. . . . .	. . . . .	Campbell's Ledge to left.
4¼ miles, . .	. . . . .	18 to 30	½ mile, ...	Swift, ...	Scoville's Island, ...	Coxton shops on left bank.
4⅝ miles,	. . . . .	. . . .	. . . . .	. . . . .	. . . . .	Lackawanna river enters on left.
5 miles, . . .	Round stones and rocks, ...	10 to 18	700 feet, ...	. . . . .	. . . . .	Lackawanna and Blooms'g railroad junction bridge, 7 piers.
5⅓ miles, .	Gravel, ...	6 to 20	500 feet.			
6 miles.						
Pittston, ...	. . . . .	. . . .	. . . . .	. . . . .	. . . . .	Shoals opposite Pittston.
⅝ mile, . . .	Large scattered rocks, ...	18 to 30	700 feet, . . .	Swift; falls 2 feet,		
1 mile, . .	. . . . .	. . . .	. . . . .	. . . . .	. . . . .	Port Griffith to left.
2 miles, . . .	. . . . .	. . . .	. . . . .	. . . . .	. . . . .	Port Blanchard to left.
2½ miles, . .	. . . . .	. . . .	. . . . .	. . . . .	Wintermute's Island, ...	Wyoming to right.
2⅞ miles, . .	Rocks, loose stones, and gravel, . .	15 to 24	500 feet, . . .	Falls about 2 feet,		
3 miles, . . .	. . . . .	. . . .	. . . . .	. . . . .	Island Ferry.	
3½ miles, . .	Loose stones and gravel, ...	15 to 36	300 feet, . . .	Falls abruptly 2½ ft		
3¾ miles, . .	do. do.	6 to 12	300 feet, . . .	Swift, ...	. . . . .	Island to right.
4 miles, . . .	. . . . .	. . . .	. . . . .	. . . . .	. . . . .	Plainsville to left.
4⅛ miles, . .	Loose stones and gravel, ...	6 to 15	900 feet, ...	900 feet wide, . .	. . . . .	Just below, 300 feet wide, swift and rough.
4½ miles, . .	do. do.	20	200 feet, . . .	. . . . .	. . . . .	Forty Fort to right.
5 miles.						
1½ miles, .	Solid rock, ...	15	100 feet, ...	Ledge of rocks, .	. . . . .	Wilkes-Barre Falls.
7 miles, . . .	. . . . .	. . . .	. . . . .	. . . . .	. . . . .	Mill creek on left.
7¼ miles, .	Rocky and gravel, ...	6	500 feet, ...	Falls abruptly 3 ft.		
9 miles.						

Stations and distances.	Character of shoals.	Depth of water.	Estimated length of shoals.	Characteristics of stream.	Local designation of shoal or vicinity.	REMARKS.
		Inches.				
Wilkes-Barre,						Bridge—730 feet long.
¾ mile,		Deep water.			Tobey's Island,	Channel for steamers 30 ft. wide, cut through gravel bar; has remained three years.
1½ miles,	Gravel,				Channel 30 ft. wide, 3 ft. deep.	
4 miles,					Tobey's Eddy.	
Plymouth,						

Respectfully yours,

H. ALRICKS, Jr.,
Assistant Engineer.

JAMES WORRALL, Esq.,
Assistant Engineer

RED BANK CREEK.

Letter from the Secretary of War, transmitting a report of the survey of Red Bank Creek, Pennsylvania.

WAR DEPARTMENT,
WASHINGTON CITY, *February 14, 1881.*

The Secretary of War has the honor to transmit to the House of Representatives, for the information of the Committee on Commerce, a communication from the chief of engineers, dated the 12th instant, and accompanying copy of report from Major W. E. Merrill, corps of engineers, upon an examination of Red Bank creek, Pennsylvania, from its mouth on the Allegheny river to Brookville, made in compliance with the provisions of the river and harbor act of June 14, 1880.

ALEX. RAMSEY,
Secretary of War.

The SPEAKER *of the House of Representatives.*

OFFICE OF THE CHIEF OF ENGINEERS,
UNITED STATES ARMY,
WASHINGTON, D. C., *February 12, 1881.*

SIR: I have the honor to submit herewith a copy of a report to this office from Major W. E. Merrill, corps of engineers, of the results of an examination made under his direction, to comply with requirements of the river and harbor act of June 14, 1880, of Red Bank creek, Pennsylvania, from its mouth on the Allegheny river to Brookville, with the view to improvement of its navigation, and with reference to its connection with a through water-line from the waters of the Ohio to those of the Susquehanna.

Very respectfully, your obedient servant,

H. G. WRIGHT,
Chief of Engineers, Brig. and Bvt. Maj. Gen.

Hon. ALEXANDER RAMSEY, *Secretary of War.*

EXAMINATION OF RED BANK CREEK, FROM ITS MOUTH ON THE ALLEGHENY RIVER TO BROOKVILLE.

UNITED STATES ENGINEER OFFICE,
CINCINNATI, OHIO, *February 5, 1881.*

GENERAL: I have the honor herewith to submit the report on the examination of "Red Bank creek, Pennsylvania, from its mouth on the Allegheny river to Brookville."

This examination was intrusted to Mr. James Worrall, civil engineer, an engineer of high standing in Pennsylvania, who has had great experience with the water-ways of the State, and has devoted much time to the study of its "through water-lines." His report is hereto attached.

It was the desire of those at whose instance this survey was ordered that it should not be limited to the small stream designated by name, but that advantage should be taken of the opportunity to make a rough reconnaissance of the water-shed that separates the West Branch of the Susquehanna river from the Red Bank and adjacent tributaries of the Allegheny. It is a noteworthy fact that the West Branch of the Susquehanna rises on the *west* side of the Allegheny mountains, and that its waters, in their course to Chesapeake bay, cut through all of the many parallel ranges into which the Appalachian chain is subdivided in Pennsylvania. Nature has, therefore, made a water-line through these mountains, and all that man need do is to increase the navigable depth, and to make a suitable connection with the Ohio.

Two routes were examined by Mr. Worrall—one by Red Bank, to its headwaters, and thence down Bennett's branch and the Sinnemahoning to the Susquehanna, being the line of the low-grade branch of the Allegheny Valley railroad, and the other by the Kiskiminetas, Black Lick, and Two Lick, and thence to the West Branch of the Susquehanna at Cherry Tree. The two lines have a common starting-point on the Allegheny at the mouth of the Kiskiminitas, and they unite on the Susquehanna at the mouth of the Sinnemahoning.

These two routes, with the one by the way of the Kiskiminitas and the Juniata, which was examined in 1878, (Report of the Chief Engineers, 1879, page 1388,) are the only routes by which through water-lines can be carried across Pennsylvania, so as to connect the waters of the Ohio with the ocean. While the means available was wholly inadequate to pay for the vast amount of labor and study that would have been required in order to secure on each route definite locations and reliable estimates of cost, it it is yet believed that sufficient information has been obtained from our own surveys and from the archives of Pennsylvania to enable us to give estimates and details that will not be greatly in error. They will at least give a fair idea of the magnitude of the undertaking, and of the advantages

of the three lines as compared with each other and with similar lines in other States.

The main points of interest on these three lines are concisely summed up in the annexed table:

Through water-lines in Pennsylvania connecting the Ohio river with Chesapeake bay.

	PITTSBURH TO HAVRE-DE-GRACE VIA—		
	Allegheny, Kiskiminetas, Juniata, and Susquehanna.	Allegheny, Kiskiminetas, Black Lick, and West branch Susquehanna.	Allegheny, Red Bank, Bennett's Branch, and West Branch Susquehanna.
Length, miles,	352½	429½	419
Ascending lockage, going east, feet,	1,000	847	762
Descending lockage, going east, feet,	1,700	1,547	1,462
Total lockage, feet,	2,700	2,394	2,224
Depth of water, feet,	7	7	7
Size of locks, feet,	20x120	20x120	20x120
Elevation of summit level above mean ocean level, feet,	1,700	1,547	1,462
Summit tunnel, miles,	5⅙	1	1
Cost of summit reservoirs and feeders,	$3,275,000	$3,000,000	$3,000,000
Total cost,	$40,000,000	*40,431,000	$39,725,000

* Or exactly $40,430,659.

For further details reference is made to Mr. Worrall's report, and to the report on the Kiskiminetas and the Conemaugh, which was printed as H. Ex. Doc. 105, Forty-fifth Congress, third session, and which may also be found in the report of the chief of engineers for 1879.

The only navigation now in operation on the Red Bank is rafting. As this stream has a total fall of six hundred and forty-nine feet in seventy miles, or at the rate of nine and three tenths feet per mile, it is evidently impossible to create an ascending navigation without the use of a number of locks and dams, whose construction would not be warranted by the present conditions of commerce on this stream. All that is now desired is that the downward passage of rafts should be facilitated by the removal of rocks and other obstructions. Mr. Worrall estimates that from $25,000 to $30,000, judiciously expended, would render the Red Bank entirely safe for rafting purposes. He further recommends the construction of three "bear-trap" dams between Brookville and the Allegheny, in order to "flash" lumber down at times when the natural flow is insufficient. For three such dams he submits an estimate of $35,000.

If these dams are built by the United States, the sluice-walls should be

of masonry, as timber cribs would soon decay. This would make the cost much greater than the estimate submitted by Mr. Worrell. It would also be necessary to appoint sluice-tenders, and to provide for their salaries. This last could only be done by collecting tolls, or by annual appropriations from the Treasury. It does not seem to me that the interests to be benefited would warrant such expenditures for construction and maintenance.

But the greatest objection to these dams is that they not only do not benefit ascending navigation, where there is such, but actually injure it, by depriving the stream of its natural flow while the water is being stored up, and by making a barrier that cannot be overcome by ascending navigation unless a lock is added.

Bear traps would, therefore, only be useful to such interests as send products down stream and expect no return cargoes. As far as I know, the lumber interest is the only one that answers this description, and hence this is the only interest that would be benefited. But, unfortunately, this interest is, from its nature, a transitory one. When the original forests are cut off, rafting practically ceases.

In view of the considerations given above, and of the additional fact that lumbermen on the Susquehanna build their own "bear-trap" and "splash" dams, it does not appear advisable for the United States to inaugurate such structures on the Red Bank.

Respectfully submitted,

WILLIAM E. MERRILL,
Major of Engineers.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

REPORT OF MR. JAMES WORRALL, CIVIL ENGINEER.

HARRISBURG, PA., *February 1, 1881.*

COLONEL: I have again had the honor to have had placed in my charge a survey of one of the great water routes of Pennsylvania, the third survey of the series which has fallen to my lot, and the second in which the acceptable duty of reporting to yourself has been mine.

The duty, as specified by the Engineer Corps, is merely a survey of the Red Bank, but, as in the case of the Kiskiminetas survey, these words embrace a great deal, for the Red Bank Valley is a portion of one of the great water-ways of the State which years ago attracted great attention, and was carefully examined by an engineer of fine attainments, many of whose notes are to be found among archives of the State, a reference to which gives me an opportunity of reviving, and, as far as I can, developing the project of the old days.

As I have contemplated, then, the duty before me, it is, 1st, to report upon the most proper manner of improving the valley of the Red Bank *per se* from its heads to its mouth, and with the aid of the old archives to develop the project of a first-class water-way from the Ohio Valley at Pittsburgh, *via* the Allegheny river, the Red Bank, Bennett's Branch of the Sinnemahoning, the West Branch of the Susquehanna, and the main stem of the latter, to tide-water at Havre-de-Grace: referring also to a variation of that line traversing the valley of the Kiskiminetas to the mouth of Black Lick, ascending which stream reach the summit of one of its branches, Yellow Creek or Two Lick, and penetrating the dividing ridge reach the head valley of the West Branch of the Susquehanna not far from Cherry Tree, continuing then in the latter valley till the first line is joined at the mouth of Sinnemahoning. The survey reported to you at the latter end of January, 1879, with this survey, will have developed the only practicable routes for first-class water-ways from the Ohio Valley to the sea, passing through Pennsylvania, and it will be seen that these routes are entirely practicable, and not unreasonably expensive.

But my first duty is with the Red Bank *per se*, as that stream gives title to the survey.

The Red Bank stream rises in the north-west corner of Clearfield county, where it is called Sandy Lick; continues to bear that name while it runs through Clearfield and Jefferson counties, till it reaches Brookville, the court town of the latter county, where it is called Red Bank; soon after it divides Armstrong from Clarion county, and empties into the Allegheny river, still a boundary at a point below Brady's Bend.

The Red Bank is a stream of much more importance than it would seem to be from its shortness and apparent volume, for the reason that it passes

through an immensely valuable mineral and agricultural country, in the first place, and its capacity, as has been mentioned, to supply a first-class water communication, in the second place.

To understand the value of this and other similar streams it will be necessary for me to glance at the physical strength of the region in which they rise and which they irrigate.

Whoever has contemplated the surface of the country which is bounded by the Mississippi, the lakes, and the ocean, cannot but perceive that a very large portion of that region must have been, at one time, the bottom of an ocean, and must have retained that character for countless periods of time. The observer will not only see this, but he will see that this sea bottom was disturbed and disrupted by most probably subterranean forces, the probable consequence of which was to drive away the water, and make the ocean bottom dry land; what is visible now is an area embracing a large portion of Pennsylvania, the whole of Ohio, of Indiana, of Michigan, of Illinois, a large portion of Wisconsin, and an extensive area beyond the Mississippi, and also in Canada, all of which bears evidence of having been sea bottom, and the result of sedimentary deposit. This, because over this immense region the earth's crust lies in very nearly level strata to a thickness of many thousand feet, all these strata, even the deepest of them, discovering fossil remains.

Let us suppose this ocean to have been in existence, and then let us imagine the convulsion which raised the Appalachian series of mountains when the force that produced that change at the surface was in full effect, the Sierras were the consequence; but withdrawing from these Sierras, we would only find that the ocean bed, miles in thickness, was simply raised from its location forming an inclined plane descending from the foot of the mountain chains in a direction at nearly right angles with the internal disrupting force which exerted its energy in a direction northeast and southwest. To illustrate a little more clearly the effect produced upon the ocean bed, let us suppose a mill-pond, which has been raised by a freshet some feet above its usual level, and that at the shore of the pond exists a line of rocks rising a few feet, say two or three feet above the surface of the shore. Let the freshet have completely submerged this line of rocks and then a frost to set in sufficient to create ice of, say, a foot in thickness. In this state of things let the mill-pond subside, when it will be found that the ice which covered the rocks will have rested on the top of them, and then be broken or cracked and will form an inclined plane inclining toward the axis of the pond.

This is exactly what took place at the creation of the Allegheny Mountains, except that in their case the range of rocks rose instead of the water falling; the ice, so to speak, was raised by the rocky range instead of subsiding upon it, but the phenomena resulting was precisely the same in both cases—the stratification formed an inclined plane in a direction *from* the Sierra.

It is only a small fraction of these inclined planes with which this report has to do, the portion namely north and west of the Allegheny Mountains in Pennsylvania, embracing the area bounded by the left bank of the Ohio and the Allegheny and the western base of the mountains. This space of country it is impossible to estimate the value of, that value being so great. It is for the most part permeated by coal, iron ore, limestone, fire-clay, large portions of it covered even yet by valuable timber and almost *passim;* wherever it has been tapped it has spouted oil; whilst, when cleared, its gentle undulations yield the wealth of a rich agricultural and pastoral country. Strange that some of these characteristics, yet not all of them by any means, nor but few of them for certain, extend beyond the body of the stream, whilst between the mountain and the stream there is hardly a point at which all or nearly all of these sources of wealth are not to be found. The area alluded to may be said to commence amongst the heads of the Allegheny and the Clarion, and to end at or about where the Ohio debouches into the Mississippi—inclosed by the Allegheny, Ohio, and the ridge of mountains to the east and south, and may contain about 49,000 square miles.

To convey an idea of its wealth, take Johnstown, in Pennsylvania, a point within this area. Johnstown was first chosen as an iron manufacturing place some thirty years ago, because there were some ore beds near it and it was handy to transportation. Johnstown now pays for freight alone some $1,200,000 per annum, and employs in its establishments several thousand hands.

There is scarcely a point in this whole region mentioned which has not all the same sources of wealth quite as handy to it as they are at Johnstown. In other words the region is capable of supplying fifty more Johnstowns with the same mineral products, in the same abundance, all that is required beyond being transportation and demand. There is no exaggeration in this statement.

Let us now return to the vast plateau already alluded to as disturbed by the upheaval of the Allegheny range of mountains. The effect observable on the south and east of the summit of the great range was much more disintegrating than on the north and west. In the first vast areas which seem to have been disarranged, ridge after ridge, spur after spur, are found protruding above the general surface, a disarrangement extending almost indefinitely towards the south and east. But we have no affair with this eastern slope. What we observe upon is the gently raised stratifications, which, like great cakes of ice, rest upon the material which rose from below. The great beds present a surface inclined north and westward from the Alleghenies, gently enough even at the initiation point, but finally presenting a surface almost level, with fissures and cracks here and there inevitably due to such a movement.

The eruption has taken place and the stratifications have taken the form indicated, and are thereafter submitted to the ordinary meteorological phe-

nomena in constant activity on the surface of the earth for another immense period, for who can give the date of the rising of the Alleghenies, or Appalachians, as they are sometimes called? The process, however, goes on; the fogs rise, the rains and the snows return, the water finds crevices to run in, some larger, some smaller, the smaller being often branches of the larger, and in the region under consideration with us we find the Allegheny river, which, after all, may be called the true origin of the Ohio, the Monongahela being but a branch; the Allegheny, which finally becomes the Ohio, receiving the Clarion, the Red Bank, the Kiskiminetas, the Monongahela, and the continued series of streams passing through Western Virginia, as the Guyandotte, the Gauley, &c., all of them and their many branches starting from their first fountains in the Allegheny mountains, and passing over the gently-inclined stratifications, in the process of time giving to the country its present form, indicating that that form has been produced only by the action of waters supplied by the uniform meteorological process of centuries.

If the bottoms of all or any of these streams be examined they will be found to be smooth rocks. There is a stream, indeed, falling into this same Allegheny river, but from the right, called Slippery Rock, which exactly describes the bottoms of all the streams of the region under consideration. But what is the composition of the strata, the result of sedimentary deposit, over which these streams flow?

The idea has been broached before. In the first place the surface is richly and beautifully fertile. If it has not yet been cleared it is covered with valuable timber, and penetrating below the surface almost at random, anywhere, coal, iron ore, limestone, fire-clay, and in many places oil, are for certain to be found. In the metal, said by some to be more valuable than gold, this region is extravagantly rich. In coal, which is very easily coked, it is equally wealthy, and indeed there are many places where the coal is so pure as not to require coking.

There are places near which I have been, and of which I am informed by entirely reliable authority, where the coal, the limestone, and the ore can be transported from the mouths of the mines by ordinary wooden chutes from each into the same tunnel-head, the coal not having required coking. This I should think would bring the original cost of iron smelted under such circumstances to less than $10 per ton. This is the highest characteristic of the whole of this region that I can give; it of course declines from that down to the mere value of agricultural surface, but that is its least source of value. Its area between the Kiskiminetas and the Clarion is about 4,000 square miles, and it is permeated by the streams whose description I have already given, and these watering it in almost every direction.

It is an irresistible belief to me that these streams were left by nature as avenues to deliver this untold wealth to market; for water-ways can be constructed in this region which can either communicate with the great East or the great West, as may be required.

The Allegheny and the Ohio open a coast to these products thousands and thousands of miles in extent; the ridge dividing the waters of the east from those of the west stoops several hundred feet to admit of a water-way being passed over it toward the Atlantic ocean.

Prominent amongst these streams is the Red Bank, which, rising in the northwest portion of Clearfield county, as has been stated, falls into the Allegheny below "Brady's Bend." Its whole fall is 649 feet; and that is very nearly regular, being at the rate of about 9.3 feet per mile. Its bottom for the most part is rock, and is very smooth; hence, as a rafting stream it has very few dangerous points, these being so more as a result of sudden bends and loops, which occur rather frequently, but when there is a proper flow of water cause but little difficulty. The sum of $25,000 or $30,000 judiciously expended would make the stream entirely safe for rafting purposes. But there is another mode of improving it for downward navigation, not more costly and equally efficacious, which is worthy of consideration. Mr. John Du Bois has recently invented what he has named an adjustable dam, which applied upon this stream, and on many others in this region, would produce a downward navigation perfectly safe for more than double the length of time that such navigation can be availed of now. The invention is founded upon the bear-trap gate, as it is called, devised by Josiah White, a Pennsylvania engineer of high reputation, many years ago.

Mr. Du Bois is very extensively engaged in the lumber business on the upper waters of Red Bank, and has there employed his invention for the delivery of logs to his very extensive mills, and is constantly expending money in the building of new ones, so that the device can no longer be called an experiment.

It is described in a very few words by stating that on a platform founded on the bottom of the stream are placed two gates opening vertically the one hinging up stream, the other down; these are protected by abutments, the inner surfaces of which are smooth, so that the gates rise and fall between them as nearly water-tight as will allow of their free movement. In one of the abutments is a chamber, into which the water is admitted by a valve from above the adjustable dam, and when that valve is closed a valve at the lower end can be made to withdraw the water in the chamber. But there is an aperture in this chamber through which its water is admitted under the gates or flaps, and when that is done the superior hydraulic pressure from above causes these flaps to rise, leaning against each other, until their vertex equals in level the water above the dam, and the gates being water-tight a dam is created for the nonce between the two abutments, the cross-section of which is like the letter V inverted. If, now, the upper valve of the chamber be closed and the lower one opened, the hydraulic pressure is withdrawn from beneath the flaps and they subside to their place on the platform on the bottom of the stream, and the space between the abutments becomes a chute. In order to make the theory of

this operation plain, it may be stated that the water passing through this chute has an inclined surface from the moment it leaves the upper level, which surface meets the surface of the water below the structure, and therefore the pressure on the gates of this passing water becomes less and less until that junction is formed. But the water in the chamber retains the pressure of the refluent water above the dam, and this admitted beneath the gates overbalances the passing pressure and causes them to rise; the difference is always sufficient for the purpose, and its application can be regulated by attention to the valve, so as to cause the rise or fall to be slow or fast, at the pleasure of the manipulator; so, indeed, as they may be caused to rise or fall a quarter of an inch at a time; such is the nicety which has been attained on the construction of these useful devices.

It is plain, then, that, supposing one of these structures to exist in the stream, that a person having it in charge can make an absolute dam of it in a few minutes, and, for that matter, it can be so constructed as to act automatically, by the introduction of floats into the chamber.

The device by which the downward navigation of these streams has been heretofore improved is called the "bracket dam," a temporary structure erected upon a dam already in existence, by aid of which a large amount of water can be accumulated above the permanent dam, in which refluent water a fleet of rafts can be assembled, and when the proper time arrives the bracket dam is broken down and the fleet allowed to float upon the liberated current in hopes of keeping it until the larger river, into which the stream flows, is reached, and the rafts can be carried upon that to their destination. The clumsiness of this proceeding is manifest; the bracket dam is always troublesome and costly to build, and is always lost in its first and only employment.

But a "Du Bois dam," as it is called, can be operated as easily and as frequently as a lock, and can be used for a single raft as well as for a fleet. In high-water it is an ordinary chute; in moderate water it can always be availed of. One great difficulty in connection with this subject heretofore is the different times in which rafting floods exist in this series of streams. The Allegheny may be in excellent order for navigation when the tributary continues vexatiously low, and *vice versa*. But were these streams supplied with a few, a very few, "Du Bois dams," telegraphic communication from the Allegheny could be sent up stream, and in a few hours a fleet of rafts might be sent down to avail themselves of the Allegheny water.

I have most carefully examined Red Bank in reference to this method of improving it; have consulted gentlemen connected with the lumber interest and practical raftsmen, and have come to the conclusion that these dams, to the number of three, judiciously placed in the stream, will add most materially to its capacity for downward navigation. These three should be erected from Brookville down, say one near Brookville, another at or near New Bethlehem, and a third at or near Willow Island, not far from Lawsonham. I have consulted experts in the construction of these works, and find that the utmost cost of the three need not exceed $35,000.

The effect would be that the downward navigation of Red Bank would sympathize and coincide with that of the Allegheny, which river need no longer be beheld by the lumberman of Red Bank, tantalizing him with a navigation of which he cannot avail himself for the want of a few structures of the kind mentioned, obtainable at so small a cost.

Not only Red Bank but the whole of the streams running through this region can be so improved, the tributaries as well as the main streams.

The people of this region are now at the mercy of the railroad companies whose roads permeate the land to some extent. The question was asked of them repeatedly, Why do you not open up this splendid country? And the reply was, We can never be sure but the demands for transportation will deprive us of our profits. The railroad companies ascertain the cost of our products at the mines or furnace's mouth; they then ascertain the market price at the point of delivery, and they charge as large a portion of the difference as they think the articles will bear for transportation. We can make no time-bargains with them for transportation, and we fear to trust the fate of our capital in their hands. This will be cured in the course of time by the construction of new roads; competition among them will regulate prices unless, indeed, the roads be swallowed up by some single cormorant corporation.

But if these streams and their tributaries can be so easily improved, thereby attaining reasonable transportation for a very large proportion of the products, why not grant the people these facilities; and as the markets for them, as has been stated, are to be found scattered over thousands and thousands of miles of coast, the interest is sufficiently general to bring it within the power of the United States to yield to its demands.

The coasts of the Allegheny, the Ohio, and the Mississippi are Mediterranean coasts—as much so as the lake coasts—are national to the same extent as the same number of miles of Atlantic coast would be. Cities like Pittsburgh, Cincinnati, Louisville, and Saint Louis are grand commercial capitals like New York, Boston, Philadelphia, Baltimore, Chicago, Buffalo, Cleveland, and if the government can improve the outside sea-coast and lake-coast, why may it not also improve the coasts of these inland waters?

The Allegheny is now being improved by the aid of the government. Its branches are its heads, and if on any of those branches there be products for delivery, why not improve them so that the delivery may be made and the whole system of improvement be brought into homogeneity?

The sum of $35,000 for these adjustable dams and an additional sum of $25,000 expended upon the correction of some few rough points on Red Bank would open up to an immense extent the vast riches of the region watered by it; so as to avail of it to the capacity of the improved Allegheny to carry it to market, and also relieve the people of the discriminating tendencies of the great railroad corporations who have already constructed works of great cost in order to monopolize the transportation of the region.

Then, Red Bank improved, the improvement of its branches would fol-

low, for, as has been said, they all possess the same general features. Indeed, all the streams of this vastly wealthy region are alike; their beds are all alike—"slippery rocks," like the little creek in Butler county. Nothing can be easier than their improvement, on account of the perfect foundations that their beds invariably present. The fall is always gentle, and the freshets never very large in volume, a result of the gentle fall. If such a system of improvement were adopted there might be some hope of opening the region advantageously to the whole public, but so long as transportation is regulated by the judgment of interested individuals, and not (as is the case with almost every other general necessity) the laws of supply and demand, enterprise is strangled in its cradle or falls into the hands of monopolists who think of nothing but the aggrandizement of the special enterprise in which they happen to be interested.

But Red Bank is to be considered in another and very important light, as being, namely, upon the route of one of the grand water-ways from the valley of the Ohio to the sea. Such a water-way fit for boats, say three hundred tons capacity, would, starting at Pittsburgh, proceed up the Allegheny to the mouth of Red Bank, follow that stream to a point in Clearfield county where the waters of the Allegheny and the West Branch of the Susquehanna head, which ridge would be tunneled, the tunnel serving as a summit level for this grand canal.

Emerging from the tunnel, the valley of Bennett's Branch of the Sinnemahoning would be used until the valley of the main Sinnemahoning would be reached and followed until it connects with that of the West Branch of the Susquehanna; down this last the work would progress until the main Susquehanna would be joined at Northumberland, along which the work would progress until it would terminate at Havre-de-Grace, being tide-water on the Chesapeake Bay.

In connection with my investigation of Red Bank this grand improvement has naturally suggested itself, and I have most fortunately been enabled, by consulting the improvement archives of Pennsylvania, to report not only upon the Red Bank route, but also upon a variation of it, which, in like manner, ascending the Allegheny, avails itself of the Kiskiminetas and Black Lick waters, and crossing the same grand dividing ridge of the eastern and western waters mentioned, near Cherry Tree, in Indiana county, strikes the headwaters of the main West Branch, which it follows until it meets the first line at the mouth of the Sinnemahoning.

From the western boundary of the State in a northeast direction the main Allegheny ridge is the dividing ridge of the Potomac, the Susquehanna, and the Ohio waters.

This great ridge, or Sierra, continues on its northeast course, but after reaching, say, Centre county, ceases to be the divide, for at or near Lock Haven it ceases to perform that function, as near that point there is a gap in it which permits waters from the north and west to pass through it. The real divide is an elevation of the sedimentary rocks mentioned before,

which, originating in Cambria county, passes through Indiana, Clearfield, Elk, and McKean in a varying northern and eastern direction, serves as a divide for the Allegheny and the West Branch waters, and even sends some water over into Lake Ontario. This is not a mountain like the great Allegheny ridge. It is an unevenness in the great alluvial or diluvial plain heretofore spoken of. It is not a mountain, for its average height must be 1,000 feet lower than the top range of the Allegheny, and its depressions are some 500 or 600 feet lower than those of the Allegheny mountains, save the break or gap near Lock Haven, which sinks almost to the base of the protuberance. This feature in the physical geography of Pennsylvania places the heads of the west branches of the Susquehanna on the opposite slope of the Allegheny mountain to that from which the southwestern waters of the same river derive their sources.

The Juniata has some heads in Cambria county, and so has the West Branch of the Susquehanna. These heads are very near each other, but the water wanders in directions totally different from each other. Those of the West Branch trend north and east for many miles, then turn south, passing through the Lock Haven depression. At Northumberland they meet the North Branch waters and constitute the main stem, continuing down which for forty or fifty miles meet their old companions of Cambria county at the mouth of the Juniata.

The low summit of the northern divide invites works of internal improvment in that direction ; five hundred feet of elevation is a great saving in transportation, and the minds of statesmen and engineers were early directed to the topographical facts I have alluded to. The Juniata waters, however, got the preference in the early day on account of the shortness of the line to Pittsburgh, and hence the main line of the Pennsylvania improvements took that direction, whilst the higher order of engineers and the more far-seeing statesmen projected, even at that period, "a Wet Canal" in that direction, or a canal without a summit portage. This system is fully treated of in your report on the Kiskiminetas and Juniata route. But a connection with the lakes was then thought of, and that connection brought out the plans for crossing the low northern divide.

Colonel Benjamin Ayerigg, an engineer of skill and activity in that early day, developed the northern route and hoped to make even the Ohio connection, cross the lower ridge branching north at the mouth of Red Bank and passing, via the Allegheny river, by way of Franklin, French creek, &c., and striking the lake at Erie, whilst his line took down the Allegheny from the mouth of Red Bank so as to reach the Ohio valley at Pittsburgh.

This system of Colonel Ayerigg's would have been the shortest possible water-way to the lakes, at least it would have been as short as the shortest, for the Kiskiminetas route might have branched at the mouth of that stream to Franklin via the Allegheny. His system, however, would have been, as he reported, sixty-nine miles longer than the old "main line," as it was called the Juniata and Kiskiminetas route, but it would have had about five

hundred feet less elevation than the more southern route, and he thought it worthy of consideration on that account. Certain it is that there are two grand routes for a water-way from the Ohio to the sea through Pennsylvania. The first via Allegheny, Kiskiminetas, Conemaugh, Juniata, and the Susquehanna; the second via Allegheny, Red Bank, Sandy Lick, Bennett's Branch of the Sinnemahoning, the Sinnemahoning itself, and the West Branch of the Susquehanna down to the mouth of the main stream. This last having a variant using Kiskiminetas and Black Lick waters, and striking the West Branch of the Susquehanna proper near Cherry Tree, following it to the mouth of Sinnemahoning and there joining the first line; this as before mentioned.

As the Kiskiminetas and Juniata line has been heretofore treated of, it needs but to refer to its proper report. It is with the Red Bank line and its variant that this report has to do.

The variant will be somewhat the longer of the two, but they are both practicable for a three hundred ton navigation; and if water-ways should ever come into use again, both these lines will be built. These summits will be, the Red Bank 1,465 feet, the Black Lick (or Cherry Tree) 1,547 feet, above the level of the sea; and both will require a tunnel of about a mile in length.

We surveyed the Red Bank from its mouth to about twelve miles east of its summit, or until we could judge for ourselves that Bennett's Branch valley could be improved for a water-way of the size proposed. We have cross-sections of the divide at the head of Sandy Lick (Red Bank,) and also at the ridge near the back slope of the Allegheny mountain, and have reconnoitered the ridge for a distance of some twenty miles. We had not means to make a hydrographic survey of this ridge, but we had Colonel Aycrigg's surveys to refer to, who had, as long ago as in 1836, found that there was water-shed enough available here to fully supply a canal of the size proposed. We, by inspection, found enough of reservoir room; and Colonel Aycrigg has given us ample water-shed. On the Kiskiminetas survey we found we could avail ourselves of, say, one hundred and five square miles of water-shed. We have not the least doubt but we shall have at least that amount here; and beyond that all we want is storage room, which we have here in abundance. A survey in detail would have found us in the field to-day, with our funds exhausted. Yet we feel as certain of our essential facts as if the survey had been continued until to-day. We say, then, that whether it be for the Black Lick and Cherry Tree route, or the Red Bank and Sandy Lick route, our system of reservoirs will cost about the same as the system required for the Kiskiminetas crossing; whilst our tunnels here will be only a mile long, whereas the Kiskiminetas tunnel exceeded five miles.

This northern line, Red Bank, will be in length some seventy miles longer than the other; but its summit level will be some two hundred and forty feet lower, setting four hundred and eighty feet of lockage against some seventy miles distance around.

But a great railroad has availed itself of this route, on account of its gentle gradients, although the additional length incurred is about one hundred miles; and if elevation is so important to railroads, why is it not equally important on canals? The cause of all the labor in this world may perhaps be referred to the laws of gravity. All labor may be referred to what machinists call "foot pounds," so that the "foot pound" (or pound raised one foot) has represented a sort of unit of value in reference to labor. Here, then, we find that all the tonnage to pass over these canals must in the Kiskiminetas case be lifted about two hundred and forty feet higher than in the Red Bank case; the goods must be drawn horizontally over a space of, say, seventy miles more than would be the case on Kiskiminetas.

I mention the facts, not presuming to decide. I think these works will be built some day; and when they come to be built, it will be time to decide which shall first be chosen; there is work for them both; the wealth surrounding their location is simply inexhaustible.

We give profiles of the routes derived from a variety of official sources, many of these sources being found amongst the old archives. We give the topography derived from similar sources and from the field work done by ourselves this last season, whilst we have received assistance from collateral recent surveys of the variant route suggested in reference to this Red Bank plan. The work can be done, and done at our estimate. There is enough water; but should that prove insufficient at the summit, the same can be crossed upon a marine railway, a plan of land navigation which is improving every day, and though not deemed preferable by us to water navigation, is admissible in a mountainous country, where the local elevation to be overcome is not great and the distance to be passed over is inconsiderable.

The extraordinary wealth of this country will eventually call into play all the resources of transportation attainable by the inhabitants. It has been said that the whole terrain is permeated by streams, and these without exception being susceptible of improvement at small cost, appear to us to have been left by nature as a means of transporting the vast products of the earth. The Erie canal did more business last year than it ever did before in the same length of time. Is this an evidence that canals are to be forever neglected for railways? Surely it is not; and why then may we not recommend the construction of canals in this country where they are so very much wanted?

It remains, then, for us to estimate the cost of this second grand route from Pittsburgh to tide-water, and leave a memorandum to show our successors what we feel sure can be done in the way of internal navigation in the United States.

Red Bank Line, via Allegheny river, Red Bank, Bennett's Branch of the Sinnemahoning, Sinnemahoning, and Susquehanna river, to tide—Divisions commencing in the East.

This estimate is based on a slackwater navigation exclusively, for experience has proved that that system is the best, on account of the greater

expanse of water through which the boats are to pass, and the system rendering propulsion by steam much more feasible than the confined canal prism admits of. Furthermore, a dam renders a multitude of other constructions unnecessary, and with the skill now attained in their construction dams are becoming as permanent and lasting as any other construction required for an artificial means of navigation.

An estimate made for the most part from the inspection of old surveys is much more reliable for a slackwater navigation than one made from similar data for an independent canal.

The work then is estimated to cost as follows:

ESTIMATE.

Red Bank line, via Allegheny river, Red Bank, Bennett's Branch of the Sinnemahoning, Sinnemahoning, and Susquehanna river, to tide-water at Havre-de-Grace—divisions commencing in the east.

1. From mouth of Susquehanna to Northumberland:

a. Mouth of Susquehanna to mouth of Juniata (see Colonel W. E. Merrill's survey of the Kiskiminetas water-way of 1878—ten per cent. added,) 87 miles,		$5,747,500
b. From mouth of Juniata to Northumberland (see Colonel Macomb's survey of North Branch of the Susquehanna,) 38 miles,		3,800,000
2. From mouth of West Branch of the Susquehanna (Northumberland) to mouth of Sinnemahoning:		
27 dams, at $60,000,	$1,620,000	
550,757 lineal feet towing-path, at $2,	1,101,514	
264 vertical feet lockage, at $2,500,	660,000	
Contingent works, bridges, &c.,	300,000	
104.31 miles,		3,681,514
3. From mouth of Sinnemahoning to Winterburn, on Bennett's Branch:		
60 dams, at $35,000,	$2,100,000	
266,640 lineal feet towing-path, at $2,	533,280	
608 vertical feet lockage, at $2,500,	1,520,000	
Contingent works, bridges, &c.,	200,000	
50.5 miles,		4,353,280
4. From Winterburn to DuBois, Summit Division:		
9.5 miles independent canal, at $40,000,	$380,000	
1 mile tunnel, (estimated,)	1,000,000	
216 vertical feet of lockage (164 feet east of summit, 52 west of summit, at $2,500,	540,000	
Reservoirs and accessories, (estimated,)	3,000,000	
Contingent works, bridges, &c.,	200,000	
10.5 miles,		5,120,000

5. From Du Bois to Red Bank:		
60 dams, at $40,000,	$2,400,000	
348,480 lineal feet towing-path, at $2,	696,960	
597 vertical feet of lockage, at $2,500,	1,492,500	
Contingent works, bridges, &c.,	300,000	
66 miles,		$4,889,460
6. From Red Bank to Pittsburgh:		
11 dams, at $150,000,	$1,650,000	
331,584 lineal feet towing-path, at $2.50,	828,960	
113 vertical feet lockage, at $2,500,	282,500	
Contingent works, bridges, &c.,	200,000	
62.8 miles,		2,961,460
		$30,553,214

Recapitulation of Red Bank line.

1. Mouth of Susquehanna to Northumberland, (mouth of West Branch,)	$9,547,500
2. Mouth of West Branch to mouth of Sinnemahoning,	3,681,514
3. Mouth of Sinnemahoning to Winterburn, on Bennett's Branch,	4,353,280
4. Winterburn to Du Bois, (Summit Division,)	5,120,000
5. Du Bois to Red Bank, (mouth of Red Bank,)	4,889,460
6. Red Bank to Pittsburgh,	2,961,460
	$30,553,214
Doubling locks,	5,560,000
Add 10 per cent. for contingencies,	3,611,321
Total cost of Red Bank line,	$39,724,535

BLACK LICK ROUTE.

1. From Havre-de-Grace, mouth of Susquehanna, to mouth of Sinnemahoning, (see Red Bank estimate,)		$13,229,014
2. Mouth of Sinnemahoning to Cherry Tree:		
66 dams, at $45,000,	$2,970,000	
633,600 lineal feet towing-path, at $2,	1,267,200	
669 vertical feet lockage, at $2,500,	1,673,150	
Contingent works, bridges, &c.,	300,000	
120 miles,		6,210,350
3. Cherry Tree to Two Lick, (Summit Division:)		
7 miles independent canal, at $50,000,	$350,000	
1 mile tunnel,	1,000,000	
350 vertical feet lockage, at $2,500, (193 E., 157 W.,)	875,000	

Reservoirs, estimated,	$3,000,000	
Contingent works, bridges, &c.,	350,000	
8 miles,		$5,575,000
4. Two Lick to mouth of Black Lick:		
47 dams, at $35,000,	$1,645,000	
168,960 lineal feet towing-path, at $2,	337,920	
479 vertical feet lockage, at $2,500,	1,197,500	
Contingent works, bridges, &c.,	150,000	
32 miles,		3,330,420
5. Mouth of Black Lick to Kiskiminetas:		
16 dams, at $40,000,	$640,000	
140,976 lineal feet towing-path, at $2,	281,952	
163 vertical feet lockage, at $2,500,	407,500	
Contingent works, bridges, &c.,	70,000	
26.7 miles,		1,399,452
6. Mouth of Kiskiminetas to Pittsburgh, (see report on Kiskiminetas line, 1879,)		1,185,000
		$30,929,236

Recapitulation of Black Lick route.

1. Havre-de-Grace to mouth of Sinnemahoning,	$13,229,014
2. Mouth of Sinnemahoning to Cherry Tree,	6,210,350
3. Cherry Tree to Two Lick, (Summit Division,)	5,575,000
4. Two Lick to mouth of Black Lick,	3,330,420
5. Mouth of Black Lick to mouth of Kiskiminetas,	1,399,452
6. Mouth of Kiskiminetas to Pittsburg,	1,185,000
	$30,929,236
Doubling locks,	5,985,000
Add 10 per cent. for contingencies,	3,691,423
Total cost Black Lick route,	$40,605,659

It will be perceived that this means of crossing the State by a grand water-way turns out in cost to be almost identically the same with the Kiskiminetas route.

This, however, will be the longer by some sixty-five to seventy miles, and the Black Lick route exceeds in length the Red Bank route about twenty-five miles, caused, chiefly, by the meanderings of the West Branch of the Susquehanna.

The summit divisions are reported in cost without going into detail.

It has been stated that we had neither means nor time for a hydrographic survey of the summit ridge; but we had our old Kiskiminetas data and we

had elementary data here from which to form a comparative estimate. Colonel Aycrigg, who had first developed this grand water-way, reports a watershed, including some heads of the Clarion, of 250 square miles—100 for Red Bank and Bennett's Branch, and 150 for Clarion.

By reference to the Kiskiminetas report, 105 square miles is sufficient watershed, and the cost of storing it is put at something over $3,000,000. We have reconnoitered this summit, and have crossed it by survey at the heads of Red Bank, and have notes of reliable engineers for a crossing at Cherry Tree. We feel sure that the reservoir area is there, and having watershed sufficient we estimate the storing of it at a round $3,000,000, quite sufficient for the purpose, the estimate being applied to both crossings. It is a little singular that the cost of the two grand works turns out so very nearly the same—$40,000,000 would seem to be a sum ample to cover the cost of either route.

The northern route is the longer of the two by some sixty-five to seventy miles, the Black Lick route exceeding that difference by some twenty-five miles, as before reported.

It is easy to see where the cost lies. On the southern route you have some four miles extra length of tunnel and between five hundred feet and six hundred feet extra lockage, which the extra distance about balances in cost. The meanderings of the West Branch of the Susquehanna from Sinnemahoning to its heads cause the difference in length, as between the Red Bank and the Black Lick routes.

In general, it may be stated that all these routes are practicable for a canal of two hundred and eighty, or even three hundred, tons capacity. The southern route is, in round numbers, 355 miles long. The shorter of the northern routes is, say, 420 miles long, and the longer of these two routes is 445 miles long. They may be in all, in round numbers, estimated to cost the same; any one of them being set at $40,000,000.

It will be for closer investigation to determine which of the three to choose. If there were but one, and that one were any one of these, it would be worth building for the cost.

And now as to Red Bank proper, which was the stream ordered to be surveyed. The rafting difficulties of the stream would be very much ameliorated by the insignificant expenditure of $25,000, or even $20,000. The Red Bank could be brought into sympathy with the Allegheny, whenever it is navigable, by the introduction of three "Du Bois dams," at a cost of, say, $35,000; and if this experiment should prove a success, all the branches of the Allegheny capable of rafting navigation could be similarly improved, and an inestimable benefit conferred upon this immensely rich mineral region at an insignificant expense.

If the southern portion of this great plane is worth improving, why not the northern, being equally rich?

From the prominent citizens of the region surveyed our party derived much local information as to the productiveness of the country. Amongst

whom let me name the Messrs. Reynolds, at Red Bank; Mr. McCue, at Lawsonham; Messrs. Anderson and Craig, at New Bethlehem; Messrs. Garrison, Gordon, and David, at Brookville; Mr. Du Bois, at Du Bois; and several other gentlemen along the line, to whom acknowledgments are tendered.

Messrs. E. H. Worrall and F. L. Faries, assistants in the field, performed their duties reliably and acceptably: whilst Mr. B. B. Lehman rendered ample assistance in the office in drafting, &c.

I should not neglect to name Mr. George Barrett, civil engineer, whose survey of the Black Lick waters was of very great benefit to this exploration. But had it not been for the archives of Pennsylvania, which were placed at our disposal by the Auditor General of the State, Honorable William P. Schell, and Colonel Aaron K. Dunkel, Secretary of Internal Affairs, we could not have presented a report like this, which we verily believe may be relied on with the confidence which a continuous exploration in the field might have called for.

I am, very respectfully, your obedient servant,

JAMES WORRALL,
Civil Engineer, Assistant.

Major WILLIAM E. MERRILL, *Corps of Engineers, U. S. A.*

Note.

This report will be accompanied by a map of the country embraced by its details, by a similar map of the Red Bank proper, and by a reduced sketch on a scale more handy for reference than the large maps.

Memorandum as to Sizes, etc.

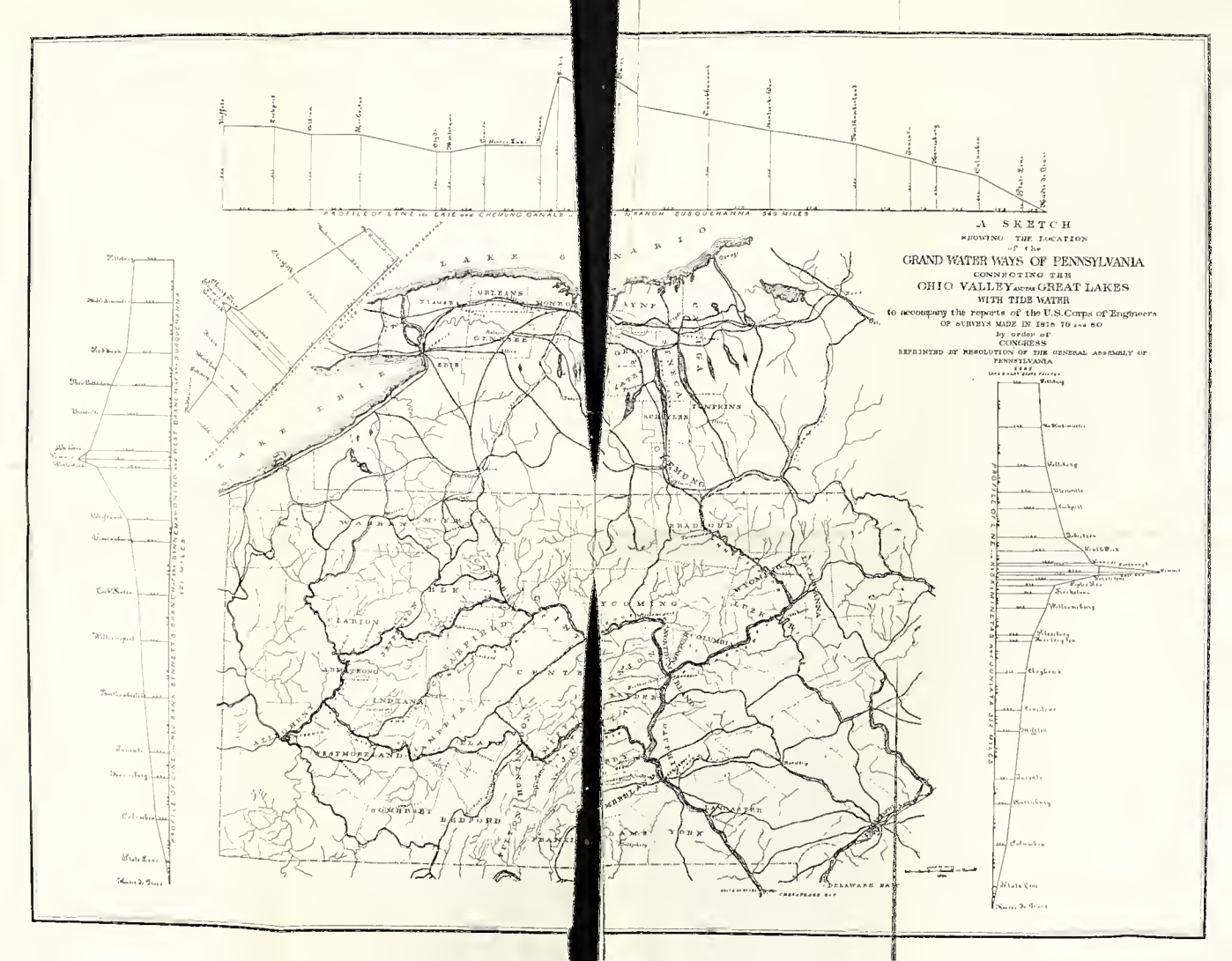
Where independent canal is to be used its prism will be 70 feet wide at bottom, with slopes 2 : 1 in earth; height of banks, 10 feet; width 10 and 12 feet respectively for towing path and berm. In rock slopes=6 inches to the foot. The locks will be 120 feet × 20 feet in the chamber between hollow quoins.

The tunnel will be 28 feet high by 42 feet wide, admitting a 9-foot depth of water, which, as the tunnel is the summit level, may sometimes be required.

Erratum.

After the profile of the Black Lick alternate, which appears upon the sketch, was made, an error in the original State paper, although sanctioned by very high authority, was discovered of 16½ miles in the distance between Cherry Tree and the mouth of Simemahoning, the old document making the distance to that extent too long. This is an error merely in length, the elevations being correct; so the length of the Black Lick alternate, as in the report, is to be reduced by 16½ miles, and its total cost by the sum of $175,000. The error does not appear in the regular map accompanying this report.

NOTE.—The sketch accompanying this re-print would be much improved by tracing the lines of the proposed great works in red or carmine ink. As the sketch is printed photographically, it was erroneously supposed, until too late, that the two colors could not be easily copied, and hence that provision was neglected. J. W.


A SKETCH
SHEWING THE LOCATION
of the
GRAND WATER WAYS OF PENNSYLVANIA
CONNECTING THE
OHIO VALLEY AND THE GREAT LAKES
WITH TIDE WATER
to accompany the reports of the U.S. Corps of Engineers
OF SURVEYS MADE IN 1878 TO 1880
by order of
CONGRESS
REPRINTED BY RESOLUTION OF THE GENERAL ASSEMBLY OF
PENNSYLVANIA
1881
PROFILE OF LINE via ERIE and CHEMUNG CANALS
PROFILE OF LINE via NORTH BRANCH SUSQUEHANNA 340 MILES
PROFILE OF LINE via ERIE and BEAVER CANALS 313 MILES
PROFILE OF LINE via BEAVER and NEW CASTLE BRANCH CANALS 301 MILES
PROFILE OF LINE via BEAVER and BEAVER BRANCH CANALS 301 MILES
PROFILE OF LINE via ALLEGHENY and WEST BRANCH SUSQUEHANNA 321 MILES
LAKE ERIE
LAKE ONTARIO
ERIE
CRAWFORD
MERCER
VENANGO
WARREN
FOREST
CLARION
JEFFERSON
CLEARFIELD
CENTRE
INDIANA
WESTMORELAND
SOMERSET
BEDFORD
FRANKLIN
TIOGA
POTTER
MCKEAN
ELK
CAMERON
LYCOMING
SNYDER
UNION
NORTHUMBERLAND
COLUMBIA
MONTOUR
SULLIVAN
WYOMING
LUZERNE
SCHUYLKILL
DAUPHIN
LEBANON
LANCASTER
YORK
ADAMS
DELAWARE BAY
CHESAPEAKE BAY